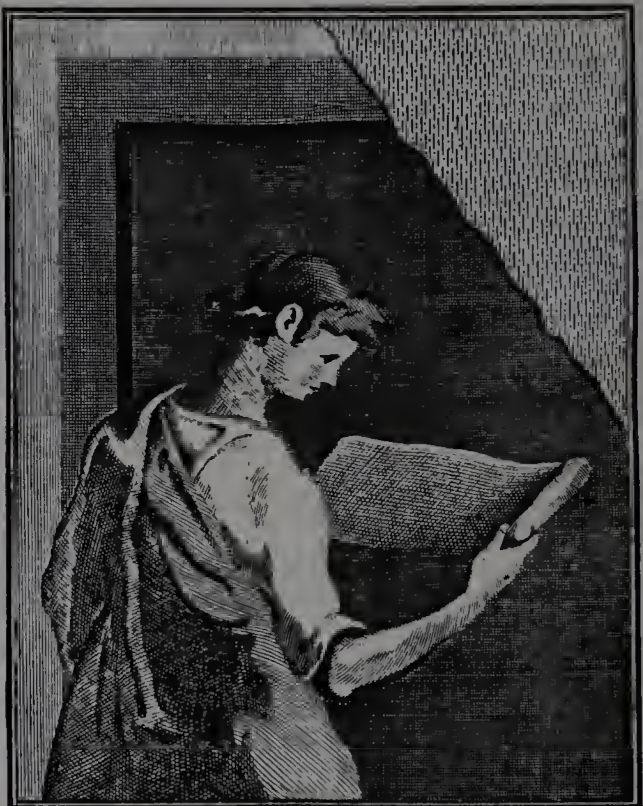

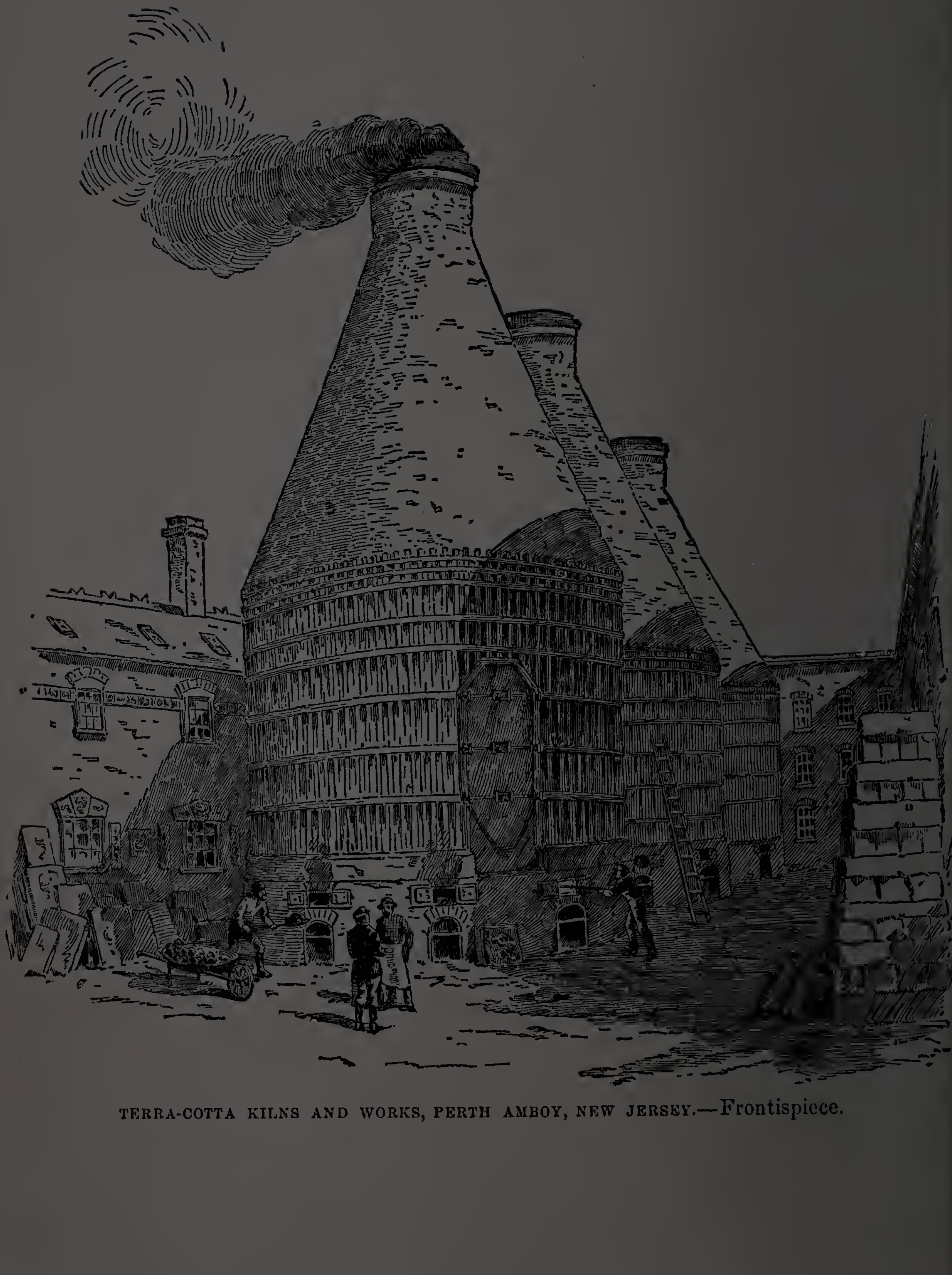

TERRA-COTTA KILNS AND WORKS, PERTH AMBOY, NEW JERSEY.—Frontispiece.

W. E. Bunn
from M. G. B. 1894

A PRACTICAL TREATISE

ON THE MANUFACTURE OF

BRICKS, TILES, TERRA-COTTA, ETC.

INCLUDING

COMMON, PRESSED, ORNAMENTALLY SHAPED AND ENAMELLED BRICKS, DRAIN TILES, STRAIGHT AND CURVED SEWER PIPES, FIRE-CLAYS, FIRE-BRICKS, TERRA-COTTA, ROOFING TILES, FLOORING TILES, ART TILES, MOSAIC PLATES, AND IMITATION OF INTARSIA OR INLAID SURFACES, COMPRISING EVERY IMPORTANT PRODUCT OF CLAY EMPLOYED IN ARCHITECTURE, ENGINEERING, THE BLAST FURNACE, FOR RETORTS, ETC.,

WITH A HISTORY AND THE ACTUAL PROCESSES IN HANDLING, DISINTEGRATING, TEMPERING, AND MOULDING THE CLAY INTO SHAPE, DRYING NATURALLY AND ARTIFICIALLY, SETTING AND BURNING, ENAMELLING IN POLYCHROME COLORS, COMPOSITION AND APPLICATION OF GLAZES, ETC., INCLUDING FULL DETAILED DESCRIPTIONS OF THE MOST MODERN MACHINES, TOOLS, KILNS, AND KILN ROOFS USED.

BY

CHARLES THOMAS DAVIS.

ILLUSTRATED BY 228 ENGRAVINGS AND 6 PLATES.

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TO

GENERAL MONTGOMERY C. MEIGS, U. S. ARMY,

I DEDICATE THIS VOLUME,

AS A TESTIMONIAL OF RESPECT FOR HIS HIGH PERSONAL CHARACTER,
AND APPRECIATION OF HIS ABILITIES AS AN

ENGINEER AND ARCHITECT.

CHARLES THOMAS DAVIS.

PREFACE.

THE manufacture of bricks, tiles, and terra-cotta, as well as a consideration of the modern methods and appliances by which they are produced, has never heretofore been practically treated in any work.

Only those who have attempted to compile a technical book under such circumstances can appreciate the labor involved.

In the preparation of the present volume the author, in default of assistance that could be gathered from other books on the same subjects as those herein treated, has been compelled to rely principally upon his experience acquired during the practice of his profession as an architect, as the proprietor of numerous buildings constructed under his personal supervision, and also as a manufacturer of bricks.

But as compensation there is the satisfaction of knowing that a new path has been laid out, and that an attempt has been made to penetrate where none other has led.

The author has endeavored to make the work interesting, but at the same time he has not allowed any matter of technical value to be superseded.

From the combative manner in which portions of the work have been written, it is probable that the author will be subjected to criticism in some quarters; but this he hopes will be just, knowing that he has been conscientious in his utterances.

It would have been a pleasant task to enlarge more fully upon the history of the different branches of pottery. An irresistible law of our nature impels us to seek acquaintance with

past events in connection with matters under discussion, not so much to gather practical ideas as from interest.

The adobes, as well as the burned and enamelled bricks of Assyria and Chaldea, possess for us a fascination, telling as they do a history of high civilization, and recalling the times when the plains of the Tigris were densely peopled with a rich and commercial population, when grandeur and beauty were the rule in architecture.

Babylon and Nineveh seem like a dream of the past, but the great perfection to which the art of enamelling bricks attained in those places has not been equalled by us.

In this branch of knowledge there is room for improvement, progress having been impeded by the difficulty in acquiring information concerning the preparation and application of enamels to clay surfaces. This want the author has endeavored to supply, and sincerely hopes that his efforts will prove a valuable aid to those in search of such information, as well as other and more common special branches of brick and tile making, herein treated.

The rapid development that is being made in America in all branches of mechanics and the arts challenges universal admiration, and is unsettling the commerce of the world.

Believing detailed information regarding the construction of the machines described in this volume desirable, not only by those who use but those also who manufacture brick and tile-making machinery, the author has in the majority of cases attempted to supply it, and hopes that some new ideas will be suggested to those interested.

CHARLES THOMAS DAVIS.

WASHINGTON, D. C.,
1114 PENNSYLVANIA AVENUE,
MAY 20, 1884.

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THE

MANUFACTURE OF BRICKS, TILES, AND TERRA-COTTA.

CHAPTER I.

THE HISTORY OF BRICKS.

BRICKS have been employed from the earliest times in the execution of many undertakings of grandeur and magnitude. The object of this volume is to give not more than a synopsis of the history of the art of brick-making, but rather to describe the practical details of their manufacture, as a complete history would be analogous to that of civilization with its advances and declines, for the authentic record of this branch of pottery is older than that of any other ceramic production, extending through forty-one centuries; the descendants of the sons of Noah, who journeyed from the East and located on the plains of Shinar being the first potters of whom we have positive attestation.

They branched out boldly in this line, when in 2247 B. C. they said: Go to, let us make bricks, and burn them thoroughly. And they said: Go to, let us build us a city, and a tower whose top may reach unto heaven. Genesis xi. 3, 4.

The story of the manner in which this proposed monopoly of that portion of space between earth and heaven was

defeated by confusion of the tongues of the builders, is too familiar for repetition here. But that something was accomplished will appear from the speech of Moses to the Israelites, delivered seven hundred and ninety-six years later, in which cities in the land of Canaan are referred to as being great and walled up to heaven. Deut. i. 28.

Progress in brick-making has often been slow and uncertain; it has flourished in ages of prosperity with other arts, and like them it has been lost in ages of darkness; but with them it awoke with the renaissance and is steadily improving with the progress of time and the spread of knowledge.

Machinery is doing much to lighten labor; but in all ages the work required to make bricks has been of the hardest kind, and many have been faint with toil in their production, in modern as well as in ancient times.

The children of Israel, as early as 1706 B. C., were made to serve the Egyptians with rigor, and their lives were made bitter with hard bondage in mortar and in brick, and Pharaoh in 1491 B. C., in order to increase the burdens and labor of the Israelites, commanded the taskmasters, saying: Ye shall no more give the people straw to make brick, as heretofore; let them go and gather straw for themselves; and the tale of the bricks, which they did make heretofore, ye shall lay upon them. Exodus vi. 7, 8.

Pictures illustrating the above passages are still preserved on tombs in Thebes, in which some of the laborers are represented carrying water in large pots to temper the clay; others carry on their shoulders large masses of clay to the moulder; while others still are off-bearing the bricks and laying them out on the ground to dry, the dried bricks

being carried in yokes suspended from the shoulders of bowed and weary laborers. Taskmasters, who were personally responsible for the labor of their gangs, are plentifully represented, observing that there was no shirking of the labor, or slighting of the work.

The mud of the Nile is the only material in Egypt suitable for brick-making; the modern plan is the same as the old: a bed is made, into which are thrown large quantities of cut straw, mud, and water, and this is tramped into pug, removed in lumps, and shaped in moulds, or by the hands. The moulded clay is sun-dried, not burned, the bricks of Egypt, both ancient and modern, being adobes.

The men on the plains of Shinar who said: "Let us make brick, and burn them thoroughly," fully understood their business. All bricks that are intended to support weight, or that are exposed to the weather, should be thoroughly burned. Partly burned bricks soon decay from the action of frost, and are easily crushed in comparison to well-burned bricks. A badly made brick may be thoroughly burned and possess great strength; while, on the other hand, a well-made brick may be partly burned, and have but little strength.

The Tower of Babel was built of well-burned bricks, as were also the exposed faces of the walls of Babylon. Herodotus, the oldest Greek historian, testifies that the walls of this city were built of bricks made from the clay thrown from the trenches surrounding the place. Accounts of the extraordinary mounds of bricks at Birs Nimrod, the supposed site of Babylon, and the remains of other ancient cities of the stoneless plains of the Euphrates and Tigris,

have been given by noted eastern travellers. The buried palaces of Nebuchadnezzar have for a long series of years provided bricks for all the buildings in the neighborhood; there is scarcely a house in Hillar, a city of over 8000 inhabitants, built close to the ruins of ancient Babylon, which is not almost entirely built with them. "To this day," says Layard, "there are men who have no other trade than that of gathering bricks from this vast heap, and taking them for sale to neighboring towns and villages, and even to Bagdad. Many bricks found in this ruin are coated with a thick enamel or glaze. The colors have resisted the effects of time, and present their original brightness."

On every brick that was made during the reign of Nebuchadnezzar it was his custom to have his name stamped, and Sir Henry Rawlinson, the oriental scholar, in examining the bricks in the walls of the modern city of Bagdad, on the borders of the Tigris, discovered on each brick the clear traces of that royal signature. The Babylonish bricks were usually of three colors—red, pale yellow, and blue; and also in all ancient Egyptian decoration, the primary colors, red, yellow, and blue, were principally employed; green was the only secondary; to which were added black and white.

The profuse employment of colored decoration is the distinctive feature of Babylonish architecture, the bricks being stamped out of a mould, and impressed with cuneiform inscriptions, which is a certain form of writing, the component parts of which may be said to resemble either a wedge, the barb of an arrow, or a nail, the inscription being placed in a sunken rectangular panel.

The sizes of the Babylonish bricks vary, the burned ones

being 13 inches square and 3 inches thick; the adobes or sun-dried bricks measuring from 6 to 16 inches square, and from 2 to 7 inches thick. The adobes were laid in clay, the work being striped horizontally, every four or five feet in height, with thick layers of reed matting steeped in bitumen to form the bond; the burned bricks were laid while warm in hot bitumen, the bond being formed in the laying. In addition to the above kinds, there were triangular bricks for corners of walls, and wedge-shaped bricks for arches, which were sometimes concave below and convex on top.

Recent excavations have been made on the site of the Pithon, the treasure-city built by King Rameses II. with the bondage labor of the children of Israel. The buildings prove to have consisted almost entirely of tremendous storehouses, built of adobes; some of these sun-dried bricks were made with straw for binding, and some without it. Explorations are soon to be commenced on the site of the ancient city of Tanis, the capital of the Hyksos, or Shepherd Kings, one of whom, it is supposed, was the Pharaoh who ruled Egypt when Joseph was carried there. Some of the mysteries surrounding that period it is hoped will be solved, and very interesting developments are looked for when these researches are begun.

It is thought that the business of brick-making was a royal monopoly in Egypt, as a very large number of bricks are found in that country with the stamp of Thothmes III., who is believed to be the prince who reigned at the time of the Exodus of the Hebrews.

The bricks of this prince are impressed with his cartouche,

which is an oval, on which the hieroglyphic characters used for his name were stamped, and the adobes made by him were 12 inches long, 9 inches wide, $6\frac{2}{3}$ inches thick, and one in the British Museum weighed 37 pounds and 10 ounces.

Colored bricks, as a means of external decoration, were extensively and very effectively used in the highly ornamental architecture of Italy and Germany during the Middle Ages. The works of Ruskin, Street, and others, have revived the taste for ornamental and polychrome brick-work, which promises to revolutionize the ecclesiastical and domestic architecture of Europe and America, and the taste for this class of brickwork has been gradually developing, and has resulted in the great advance that has been made in the manufacture of colored, relief, moulded, and intaglio bricks during the past few years, until it now bids fair to rival the standard of earlier ages. In sympathy with the demand for a higher grade of ornamental bricks, there is a more exacting standard as to the quality of the common building bricks used, and architects and engineers now generally require that all bricks shall be sound and thoroughly burned. When this is so, they are of a clear and uniform color, and when struck together they will ring with a sharp metallic sound; inferiority is plainly manifest when there is a deficiency in either of these points.

The great perfection to which the ancients carried the art of brick-making is probably due to the abundance of labor; plenty of time to devote to each stage of the work, their great patience and painstaking, and the natural drying and preserving climate of the east. The dry, warm atmosphere

of Egypt, Assyria, and Babylonia, which countries were the nurseries of the ceramic arts, has kept in a good state of preservation for more than 3000 years the sun-dried bricks so common in those countries; many well-preserved adobes are also found in towns and walls of ancient India.

Bricks burned and unburned were employed in the construction of the Great Wall of China, which was the most remarkable fortification ever erected by human hands; millions of men were employed for the space of ten years in its construction, and it was completed in 211 B. C. The length was about 1250 miles, the height averaging about 22 feet; each face of the wall was built of hewn stone or brick, and filled in between with earth; it was wider at the bottom than at the top, which was sufficient for six horsemen to ride abreast, and it was built by the great emperor of China, Shee-Hoang-Ti, who is its national hero.

It is probable that burned clay did not find great favor with the ancient Greeks, as they possessed an abundance of stone, and their early and beautiful temples were built of that material.

The walls of Athens, on the side toward Mount Hymettus, were built of bricks, and this is probably the largest undertaking in which they were employed by the Greeks.

The use of bricks for architectural construction was never, at any period, extensive in Greece; but in some few cases they were employed in minor public edifices.

Their first application has been attributed to Hyperbius, of Crete, and Euryalus or Agrolas. The bricks were made with a mould, and were named after the number of palms—length.

In the first century of the Christian era while the bricks made by the Romans were of a superior quality, those made by the Greeks were very inferior.

But little is known of the material used in the early buildings of the Latin cities; yet judging from the great extent and destructiveness of the fires in Rome, it is inferred that wood entered largely into the construction of buildings to the time of Nero. During his reign in A. D. 64, two-thirds of the city was destroyed by fire. Augustus, who devoted so much time and thought to the beautification of Rome, had restricted the height of buildings to seventy feet; but this height was still further curtailed by Nero after the great conflagration, and in the rebuilding, a certain part of the houses were constructed of a fire-proof stone from Gabii and Alba.

With the conquest of Carthage, Greece, and Egypt, the Romans became acquainted with the arts of those subjugated countries, and tried to improve upon and use them for the embellishment of the imperial city, and it was most likely their innate desire for improvement that led to the burning of bricks in kilns.

Although burned bricks were used in the Tower of Babel, and, to face the adobes used in the building of the walls and palaces of Babylon, it is probable that the credit of first burning bricks in kilns belongs to the Romans; but it is hard to fix the time when this improvement took place.

Layers of thin bricks, separating the tufa surface into panels, called *opus reticulatum*, were used in the time of

Augustus. In the time of Nero the walls were faced entirely with excellent brick-work called *opus lateritium.*

Pliny says that the bricks made in Greece at this time were very inferior, and not fit to be used in the construction of a Roman dwelling, and that no party wall was allowed to be more than eighteen inches in thickness, and that the material would not support one story.

The bricks must have been of a very poor quality, or else Pliny greatly misjudged their strength, for at the present time many buildings are being constructed, four and five stories in height, with the party walls for most of the way only nine inches in thickness, of the poorest kind of salmon bricks of which the water has barely been driven out of the clay by the action of heat; and if Pliny could see some of the bricks now used, he would quake for the safety of the occupants of some modern hotels, apartment houses, office buildings and dwellings that have recently been erected for speculative purposes in London, and some portions of this country.

In the first century of the Christian era, the bricks were better than at any other period; they were large, flat, and thin, generally two feet square, and one inch thick, and were what we call Roman tiles, but were used for building walls, and not merely for roofing or pavements; the facing bricks were triangular, the broad side being outwards. But bricks gradually became thicker and shorter, until in the fourth century they were very often as many as four to a foot on the face of the wall; which is about the same as in modern structures.

The Romans did not build their walls entirely of bricks, they were used only as a facing or veneering; the same as we use front or pressed bricks, the remainder or backing of the wall being of concrete, and thus we find that a large number of the great Roman buildings are constructed of concrete, faced with brick.

The brick-work of the first two centuries of the Christian era, the crowning period of art in Rome, was superior to any other. In the third century, there was barely a perceptible change; but in the fourth there was a most decided deterioration, and brick-work went back with the times, old material being re-used extensively, as in the arch of Constantine.

Knowledge of the art of brick-making has probably at no time become entirely extinct in the east; but after the fourth century, in sympathy with the decline of all other arts, and the dying Roman civilization, the knowledge of this art gradually expired, and was lost in Western Europe.

The Romans made bricks extensively in Germany and in England, and though it might seem strange that such an art, when once acquired, should have been lost, nevertheless the remains of buildings between the Roman times and the thirteenth century show no evidence of bricks having been made in England.

In a few instances only were they re-used as old material from buildings left by the Romans, as at Colchester and St. Alban's Abbey, the old Roman town of Verulamium, near which the latter is situated, supplying material for it.

The buildings of the Anglo-Saxons were usually of wood, rarely of stone, until the eleventh century, and it is not im-

probable that the primitive English churches may be among the earliest stone buildings of Western Europe, after the time of the Romans.

In these buildings the arches are generally plain, but sometimes they are worked with rude but massive mouldings; some arches are constructed of bricks, all of them taken from some Roman building, as at Brixworth, or sometimes stones are employed, and these usually have a course of bricks or thin stones laid upon the top of the arch, as at Britford Church, Wiltshire.

It has been thought that bricks were made in England, under the direction of Alfred the Great, as early as A. D. 886, and it is possible that, in rebuilding London and other cities which had been destroyed by the Danes, bricks were used; but this is not probable, as there are but few buildings in any part of Western Europe now in existence that are earlier than the eleventh century, and if bricks were made in the time of Alfred, in England, there are none at present in existence, and no authentic history of any building erected in his reign, in which they are said to have been used, and it is most probable that the earliest true modern, or Flemish, brick building existing in England is Little Wenham Hall, in Suffolk, which was erected in A. D. 1260.

In the reign of Henry VI. brick construction was not general, Hurtsmonceaux Castle, Sussex, built early in his reign, being one of the principal brick buildings of that period; but under Henry VIII. and Elizabeth, the manufacture of bricks flourished, and they were used mostly for large

buildings, the smaller ones being of timber construction, in which small panels of ornamental brick-work were sometimes formed and exposed between the upright studs.

Only a few instances of early fourteenth century brick-work occur, and they are towards the close of the style; but in the fifteenth century brick-work became common, and we have in the Lollards' Tower of Lambeth Palace, built in A. D. 1454, and the Manor House, or older portion of Hampton Court Palace, Middlesex, built in A. D. 1514, good examples of the English brick architecture in mediæval times. The ecclesiastical and palatial architecture of Italy of this period is rich in many beautiful specimens of brick-work, and in addition to the employment of colored decorative brick-work, the most elaborate mouldings and ornamentation in terra-cotta and brick are exhibited.

Until the first quarter of the seventeenth century, the bricks made in England were of many different sizes; but by Charles I., in A. D. 1625, their size was regulated and made nearly uniform.

After the great fire of London, in September, A. D. 1666, brick was the material universally used in the reconstruction, and ornaments carved with the chisel were introduced into some of the brick-work erected towards the last of that century in that city.

In A. D. 1784, bricks were subjected to taxation by George III., which burden was not repealed until A. D. 1850; the tax for this time, two-thirds of a century, averaging about 4*s.* 7*d.* per thousand for common bricks, and about 10*s.* per thousand for the finer grades.

The material of which a town is built depends generally upon the geology of the surrounding district, as in a mountainous country like Scotland, cities of stone, such as Edinburgh, Glasgow, and Aberdeen, naturally abound; but London, and most of the great cities of England, being situated in alluvial valleys and plains, are built of bricks made from the alluvial clay beneath and around them, and in Holland and the other provinces of the Netherlands, where no stone, except a very soft and inferior sandstone is found, the use of brick as the chief building material became almost universal from earliest times, even the paving of the streets and other public works being done with bricks. There are buildings in some cities of the Netherlands in which stone has been largely used, but they are the exception rather than the rule. Peter Mortier, in a small book published in A. D. 1782, gives a description of the City Hall of Amsterdam. He says that the old City Hall was erected earlier than A. D., 1400, that the front and sides rested on divers stone columns, and that on one side there was a four-square stone steeple, that the building was burned July 7, A.D. 1682, and the heat was so great that everything was consumed, except a piece of brickwork in the steeple. The new building was constructed on the site of the old one, but was commenced in 1648, part of the old structure having been taken down to make room for the new. In order to obtain a foundation for the new building, 13,659 piles were driven, upon which were placed seven feet of brick-work to form the foundation.

It was under Wouter Van Twiller, of Amsterdam, a gov-

ernor appointed by the Dutch West India Company, that the first brick buildings were erected in this country. In A. D. 1633, soon after his arrival on Manhattan Island, Governor Van Twiller erected for his own use a substantial brick house, which was the most elaborate private dwelling which had up to that time been attempted in America, and during the remainder of the Dutch dynasty this dwelling served for the residence of the successive chiefs of the colony. He also built several small brick dwellings for the officers, which with his own were erected within the walls of the fort. The bricks used in these buildings were brought from Amsterdam, and were of such a good quality that but few were broken in the long and rough voyage. The Dutch seem to have succeeded well in making a strong and very durable quality of brick, which bricks have been famous from an early period for soundness, and specimens of them brought over by the early settlers from Holland are yet to be met with in some of the old Dutch houses of New York.

Among the Puritan emigrants to New England money was very scarce; and, under Winthrop, carpenters and brick-layers, whose services were in great demand, and had a monopoly price, were forbidden to accept over 12*d*., and afterwards, in 1630, 2*s*. per day, the penalty being 10*s*. to giver and taker. The brick-layers were also the stone-masons, they ranked under the first head; but a much larger amount of building was done in wood and in stone than in brick in those times.

The earliest settlement in this country in which brick-makers are recorded as being part of the population was the

colony of New Haven. In this industrious and inventive little company it is probable that the first bricks made in this country were burned in 1650. They had no rich backers willing to foot the bills for costly brick buildings, as the Dutch West India Company had done for Governor Van Twiller in his building operations at Manhattan, or New Amsterdam as it was called at a later period. They had made several attempts to produce bricks at earlier times, but had failed, and it is not probable that the very few which they did succeed in burning were of a very superior quality. But like the building of their ship, which sailed from their ice-bound shore and was never heard of again, though faulty in many respects, their production was an evidence of great energy, and it is the inheritance of this same quality that has made all that section of country a great manufacturing and inventive district.

The Virginia colonists possessed clay of a far superior quality for brick-making; but they do not seem to have made any attempt to utilize it. A few bricks were brought from England and used in the furnaces of an iron-foundry and a glass-house, both of which were destroyed during the great massacre of March, 1622, and appear to have comprised the entire manufactures of the colony.

Brick has been a choice material for building purposes in the State of Pennsylvania from its primitive days. In a letter from William Penn to his agent, J. Harrison, at Pennsbury, written in 1685, in speaking of a lady who had purchased land and intended to emigrate, he said: "She wants a house of brick, like Hannah Psalter's in Burling-

ton, and she will give £40 sterling in money and as much more in goods. It must have four rooms below, about 36 x 18 feet large, the rooms 9 feet high, and two stories height." Some idea of the great purchasing power of money in those days, as well as the price and value of buildings, can be gained from the above.

In 1705 the price of brick-layers' labor in Philadelphia was 3*s*. 6*d*. per day, and the price of bricks 22*s*. per thousand. One of the oldest public buildings in this country constructed of brick was the old Court-house in the city of Philadelphia, commenced in the fall of 1705, and to these pilgrim fathers the erection of this building was a great undertaking and their largest endeavor. Gifts, fines, assessments, and forfeitures were all combined to give it the amplitude of a "Great Towne House" or "Guild Hall," as it was sometimes called when first built. To modern ideas this building was small and ignoble; but in those days it was grand and imposing in the eyes of all the populace. The total expense of the structure was £616, the bricks costing 29*s*. 6*d*. per thousand, and the brick-laying costing 14*s*. per thousand. This primitive building was erected in the middle of High, or as it is now called, Market Street, at the corner of Second, and after being used for various purposes for one hundred and thirty years, it was demolished in the spring of 1837. For about twenty-eight years it was used as a court-house; but its use for that purpose was superseded by the erection of "the new State House," or "Independence Hall" as it is now called, which was built of brick in 1733. Another primitive brick building in that city was

the "Great Meeting-house" of Friends, at the south of the "Great Towne House," on the corner of Second and High Streets. This building and the surrounding brick walls which inclosed it, were erected in 1695, the ground being given for that purpose by George Fox, for "truth's and Friends' sake." Early in 1719 bricks came into use for foot-pavements in Philadelphia, and the great demand for them made the material very expensive.

Bricks do not appear to have been much used in the early buildings of Boston, as wood seems to have been the favorite material for building purposes with the Puritan emigrants, stone being sometimes employed. The first "Towne House" erected in Boston was constructed of wood; it was built about 1657, and stood at the head of State Street, and was consumed in the great fire of 1711. Its successor was a brick edifice, erected in 1712 on the same spot, which in turn was destroyed in the fire of 1747. The old State House was built the next year, 1748, and as late as 1791 it was described "as an elegant brick building, 110 feet in length, and 38 in breadth." The first Episcopal Church in Boston was erected in 1689, of wood, at a cost of £284, and was at the corner of Tremont and School Streets. The "Triangular Warehouse," which stood at the head of the "towne dock," was one of the earliest brick buildings erected in Boston; it was built by London merchants about 1700; its foundation was of stone and its walls of brick, which were of a larger size than the bricks of the country in later times.

Brick-work became common in this country in the early

part of the eighteenth century, and until the trouble between the colonies and the mother country, bricks were imported mostly from England.

There was not much inducement to produce home-made bricks previous to this time, as vessels sailing with light cargoes for the colonies would finish out with bricks, which commanded ready sales, at moderate prices, rather than with stone ballast, which would have to be thrown overboard before receiving their heavy return cargoes of tobacco and other exports of the colonies.

In this way a number of brick buildings were constructed on the tide waters of the Atlantic coast, in the times which preceded the troublesome period of the Revolution.

At the period immediately following this war, there was but little done in the line of building; the generally distressed condition of the industries and the finances of the country was a bar to any improvements, excepting such as were in the nature of repairs, and necessary to make buildings inhabitable. The condition of things, after the adoption of the Constitution, gradually changed; churches, and other buildings of a public character, which had remained in an unfinished state during the entire period of the war, were completed, and a few houses of a substantial character were erected in some portions of the country, home-made bricks being generally employed when they could be obtained, and the character of the buildings admitted, which was but seldom, as wood and stone entered largely into the construction of the great proportion of all buildings. The inventive genius of the new nation was not much stimulated to im-

proving on the manner of the mother country in the production of bricks. In fact, those which we then made were poorly moulded and burned, and compared unfavorably with the common building bricks of English and Dutch manufacture.

But at the present time, for both quantity and quality, we have no equal in any nation of the world, and for this we are largely indebted to the American patent system, which greatly fosters and encourages development in this line, as in other and kindred arts.

The machines for the production of bricks which are fully described in other portions of this volume are fruits of the system, and they are evidences of a high civilization, and but tokens which are in time to place the manufactures of the world under our control.

The short-sighted policy of Great Britain in charging enormous fees for patents and giving to the inventor or patentee absolutely no protection, but compelling him to go into the courts and litigate his rights, which, to a man of even moderate means, in case of defeat, brings ruin and disaster upon himself and family, retards the industries and arts of the kingdom. This ruin has been the case often, when the defeated one had absolutely the best legal and equitable rights to the disputed invention; but through the protracted struggle and ever-increasing costs he has been bankrupted, and then defeated upon points which had no bearing upon the merits of the case, but were simply technical. Their system breeds litigation; it will give you a patent for an invention to-day, upon payment of the fees; it will issue one

to a second party for identically the same invention to-morrow, upon the same terms; and next day, if I should apply, they would grant one to me, looking out for nothing but the legal fees; and so on, for any and all persons applying.

If the patent for which the three of us were granted the same rights should be valuable, a triangular legal fight would commence; one would, of course, be certain to win, and the other two would be just as certain to lose, and the chances would be that the money which two of us had paid to the government for fees, each believing that we had prior rights, would eventually be expended for our support in the almshouse, the invention having made one of us, and bankrupted the remaining two of the original equally confident trio.

Should any subject of the British government conduct his business upon the same principles that it does in the granting of patents, he would be a felon, and transportation or imprisonment would be the penalty.

Let some subject sell the same merchandise or other commodity or valuable thing to several different persons, and take full payment from each, and giving no notice of the previous sales, he would not desire to remain any longer than was absolutely necessary in reach of British law. But this is exactly what that government does all the time in issuing patents; they lose sight of the fact that they are morally bound not to accept payment more than one time for exactly the same thing. Restrictions should be immediately made in this matter and invention encouraged, not impeded, or many of their most important manufactures will

pass to us by right of extra diligence, and in accordance with all the laws of progress. The serious defect which has been noted in the English system stands in the way of that development of the industrial arts which is the aim of patent law, the intent of which it is the solemn duty of legislation to foster and safely guard, as well as to remove all impediments to its equitable and moral progress. One of the main principles of the American system is that no invalid patent shall issue, and that a patent shall only be for a new invention or discovery, and able to stand the test of litigation.

Since writing the above, and while this volume was in the hands of the publishers, the English patent law has been so modified as to issue, from January 1, 1884, letters only to the person or persons claiming to be the inventors; also largely curtailing the fees during the first four years of the life of the patent; but leaving the remainder of the law as to other fees, length of patent, and many other matters, quite in its old form. The idea seems to have been, if a patent was valuable it would develop itself during the early period, or the first four years, and could stand the other heavy taxes or fees. This is a great error; many patents are issued which are far ahead of the times at which they appear, and it requires a much longer period for development. The life of a patent is like the life of many men—the last years are often the best and most profitable in many ways. The new law provides for interferences, and allows the application to be sent by mail instead of being delivered by hand, as formerly. Other points will be noted directly.

Some few of the changes are worth imitating; but the majority of them are of but small, and no real practical value. The ground around the roots of the defects in the law has been slightly loosened, but the evil still remains, and must be wholly eradicated in order to fully stimulate the inventive genius of the masses. A country that professes to be so strongly in favor of free trade should not exempt about all the wants of the body and then tax so heavily the fruits of the mind. The patent law of England is still too much a relic of a period which is long since past, as is also its common law, and many of its customs and institutions. It is right for nations to be conservative in a moderate degree; but extremes always measure out full punishment.

The following are a few of the salient points of the new English patent law:—

The patent must contain one or more distinct claims. Heretofore it has been usual, but not necessary, to have claims.

When the complete specification is accepted, it is made public and advertised; and any one may within two months oppose the sealing of the patent for these causes: That the invention has been taken by fraud from some one; that it is already patented in Great Britain; and, that the application has been reported against as appearing to contain the same invention as a prior dated application. This opposition may be contested, and is theoretically a safeguard, but it opens the door to enemies, or to those having contrary interests, to worry poor inventors.

When the right to convey by deed begins is not stated;

it commenced previously only after the sealing of the patent. But under this new law the comptroller is made judge as to the ownership of patents, and anything which satisfies him is enough to convey the title. So that whoever he enters in the register of patents as the proprietor has absolute power over the invention, to sell it, to grant licenses, to deal with it, and to give effectual receipts for any of these things.

The owner can ask for the privilege of amending his patent, so as to disclaim, correct, or explain any part. But this must be advertised, and within a month any one may oppose it. This may lead to a contest as to what he may be allowed to modify. No change can be made to give the patentee more than, or different from, what he claimed at first.

A new departure is that the patent binds the government. The government may use the invention by agreement with the patentee, and even without that, on terms to be fixed by the treasury, after hearing the parties. But the patentee can claim payment therefor as a right, which is now recognized in him as against the crown.

The courts and committee of the privy council are empowered to call in the aid of an assessor, specially qualified, to assist in trying and hearing suits for infringements and other matters relating to patents and inventions which lawyers generally do not understand. This is a good point, and one we will need to copy.

The Board of Trade may compel the patentee to grant licenses on such terms as may be deemed just, in default of his granting licenses on reasonable terms, where it is com-

plained that the patent is not worked in the kingdom, that the reasonable requirements of the public cannot be supplied, or that any one is prevented from using another invention to the best advantage.

There are provisions adopted looking to the establishment of an international protection for inventions, trade-marks and designs, so that when a patent was applied for in one country in such union, the applicant would have seven months to make his applications in the others, without risk of loss from publication or subsequent applicants.

Nearly every civilized nation on the globe has provided in a greater or less degree for the encouragement and protection of inventive skill and industry; and for generations exclusive privileges have been granted to the producers of things new and useful in art, science, literature, and mechanics. Upon the experience and practical workings of the various systems of the Old World, our laws and practice have been founded and perfected. Prior to the adoption of the Federal Constitution, some of the States, or provincial governments, granted to inventors exclusive privileges, but for obvious reasons these were of little or no value. By act of April 10, 1790, the first American patent system was founded. Thomas Jefferson inspired it, and may be said to have been the father of the American Patent Office. He took great pride in it, it is said, and gave personal consideration to every application that was made for a patent during the years between 1790 and 1793, while the power of revision and rejection granted by that act remained in force. It is related that the granting of a patent was

held to be in these early times quite an event in the history of the State Department, where the clerical part of the work was then performed.

During the years from 1790 to 1812 inventors confined themselves almost wholly to agricultural and commercial objects. Implements for tilling the soil and converting its products and machinery for navigation attracted most attention. Manufactures, except of a purely domestic character for domestic purposes, were hardly known; the arts were poorly understood and little cultivated. The necessities of the New World drove its enterprise into other channels, and its people looked to Europe for manufactured products not directly connected with the necessities of life or demanded by the development of its commerce and agriculture. The war of 1812, however, forced our people to attempt production in many branches of manufacture and industry heretofore almost wholly uncultivated, and the result was the most remarkable development of human ingenuity ever known to any age or country. It is a source of great regret that no well-preserved history of American inventions dating from this time is in existence, and that no classified list of models which were in the Patent Office at the time of the fire in 1836 can be obtained. The earliest date that can be reached is January 21, 1823, and that is only partially complete.

Improvements in modes or machines for manufacturing common bricks received but little attention until about 1840; previously they were more remarkable for uniqueness in some special point of but small importance, than for any

generally good achievements; that is, no attention was paid to the result of the brick after it came from the kiln; the whole idea seemed to be to shape or mould it in some manner. For instance, one machine was made like a box now used by plasterers to run off their lime; it was elevated slightly, and the mud, which was mixed in the box, allowed to pass through a grate into a large framework having sides about three inches high, and divided by wires stretched the length and across it, which laid upon the bottom, and when the clay in the shallow box was somewhat hardened the wires were raised and the bricks thereby cut and formed into shape. The box, when emptied of the clay, could be easily moved on wheels running on a plank gangway, to the next shallow mould-box, and so on. But the slush stock made in this way was very inferior; it would dry unequally, be full of cracks, and was subjected to no packing, as in the pug-mill, or pressure, as by machines of to-day, or a blow, as is done by the hand-moulder, who dashes the tempered and packed clay into the mould with great force, and again forces it down and closer together with his hands and plane. When the bricks came from the kiln they were light, very open or porous, therefore absorbed water readily, and were entirely unfit for building purposes.

The brick machines which will be hereafter described have remedied these great objections in almost every particular. With every machine and contrivance which is to be described in this volume I am perfectly familiar, and have seen all in actual operation, and for this reason have selected such for illustrating the different portions of

this work. There are other contrivances and machines made in this country and in Europe that may be equally as good as some herein described, and no effort will be made to praise those which shall be used for illustrations above others which may have equal claims for consideration. The thousands of inventions cannot all be described, and rather than fall into a sea of error, so common in mechanical descriptions, I shall be compelled to select those machines the merits or demerits of which I can personally discuss.

Before any attempt is made to describe the processes or machines employed in the manufacture of bricks or the other branches of pottery, it is highly important that there should be a thorough knowledge of the character of clay, and some of its changes while under the several conditions to which it is to be subjected. This will be attempted in a general way for bricks, in the chapter which is to immediately follow, and more especially for the other subjects in the portions of the book devoted to them; for instance, fire-clays will be more fully described in Chapter VI.; terra-cotta clays in Chapter VII.

CHAPTER II.

THE DIFFERENT VARIETIES OF CLAY, THEIR CHARACTERISTICS, QUALITIES, AND LOCALITIES.

THE term clay is applied to hydrus silicates of aluminum, and is found, combined with other substances, in beds of varying depths, being produced for the most part by the decomposition of felspar rocks, and the precipitation in basins, from the suspension in water, of the finely divided impalpable particles. The rocks containing a good proportion of oxide or salts of iron form red clays, and those having only traces form white or light clays.

Pure clay or the hydrus silicate of alumina is infusible, even in the most intense heat; but when mixed with the alkalies or alkaline earths, it becomes fusible in proportion to the admixture.

Clay suitable for the manufacture of building bricks is an abundant substance, and is commonly obtained from sedimentary or alluvial deposits; but there is a great difference in the nature and quality of clays found in various localities; in Maine, the clays are light; in Massachusetts and Rhode Island they are more fatty; the Haverstraw, Croton, and other clays on the Hudson River contain an undesirable "quicksand," and the bricks made from them usually "whitewash" or "saltpetre" upon exposure to the weather.

The Connecticut and northern New Jersey building brick clays resemble those of the Hudson River; but the belt extending along the eastern portion of Pennsylvania, down through Delaware, Maryland, the District of Columbia, and the northeastern portion of Virginia contains the finest grade of loamy clay, producing a superior quality of bricks of the greatest hardness, and of a cherry-red color.

Baltimore and Philadelphia lead in regard to the quality and color of the finer grades, but the ornamental bricks produced in Philadelphia are of the highest rank. The clay formerly used in Chicago and vicinity was not only limy, but contained lime pebbles, which rendered it very difficult to work; but recently it is claimed that good banks of clay have been discovered near the city, which promise to produce superior bricks. Around St. Louis the material is of a loamy nature, with veins of what are called "joint clay," which makes the bricks crack and check in drying, and split in burning. The clays in the neighborhood of Milwaukee are of a plastic nature, and owing to only a small per cent. of iron, burn nearly white, or of a light cream color.

The clays in many portions of Canada are good for brick-making; they are especially so in the neighborhood of Amprior, Belleville, Bell's Corners, Brantford, Dundas, Glenwilliams, Kincardine, London, Pembroke, Ramsay, and Yorkville, in Ontario; and near Little River, Montreal, Quebec, and St. John, in Quebec, also at St. John, and many portions of New Brunswick. The clays found near Halifax, Springville, and Woodstock, in Nova Scotia, are passably fair for brick-making.

Good pottery clay is also abundant in many of the above neighborhoods. The best brick-clays are composed of silica three-fifths, alumina one-fifth, and the remaining one-fifth of iron, lime, magnesia, soda, potash, and water; if there is an excess of alumina over the silica, the bricks are likely to crack in the kiln; but the presence of a proper proportion of silica remedies this by rendering the bricks more porous, and good bricks have been produced when the proportion of silica reached as high as 85 per cent. of the whole body. When sand is added to the clay intended for common bricks, it should be clean, sharp, fusible, and not too fine; right selection and proportion insures a hard, strong, ringing brick, of good size and color; but for pressed, ornamental, and other higher grades of bricks, a finer sand should be used. But little can be learned, in the present state of knowledge, from chemical tests of clay and combinations of clay and silica sand; the physical tests and experiments are far superior, and the actual quantity of sand or other substances to be employed, and which are required for any clay, can only be determined by actual experimental mixing and burning.

Sandy clay or loam, and calcareous clay or marl, are largely used for brick-making; but if too much lime be present, the compound becomes too fusible. Oxide of iron is always present in building brick-clays to a more or less degree, and in the process of burning it is converted into peroxide, and imparts to the whole brick its color, more or less deep red, according to the degree of heat which the brick receives in burning, and the amount of the oxide that the clay contains.

It is of no great importance whether a clay contains a

large or small amount of sand mixed with it naturally, as all clays require more or less mixing and grinding; and when sand is to be added to clay, it is generally easiest and best mixed in such proportions as may be required while the clay is being placed in the pit, preparatory to being tempered, or if to be used for machine-made bricks, whilst the clay is being pulverized.

Clays that are rich in lime or in the alkalies, are not good for brick-making, and are the worst that can be used for the purpose; in fact, when a clay contains even three per cent. of lime, a good quality of brick cannot possibly be made from it.

Carbonate of lime, diffused limestone, and lime pebbles, when they are present in brick-clays, are a decided hinderance to the production of even a passable quality of building bricks, for in the kiln the limestone and lime pebbles are converted into caustic lime, and when the bricks are used below ground, or for exposed walls, the moisture and carbonic acid, which penetrate to every part of a brick, slack the nodules of lime, the swelling causing the brick to burst and break to pieces. Should the bricks be used for "filling in," or inside and unexposed walls, the dampness from the mortar used in laying them, and also that contained in the plastering would, by producing the same bursting and breaking, destroy the finished face of the inside walls. These are some of the evils which result from the badly made bricks formerly so freely used in Chicago, and arise from the large amount of lime pebbles in the clay, and the neglect of finely pulverizing or thoroughly sifting

the clay, which can easily be done by machinery, at but a small additional cost.

Oyster-shells and iron pyrites are not uncommonly present in clays, and in order to make a durable and well-colored brick they must be very finely pulverized or separated from the material. Clay taken from the seashore, or without or beneath the sea-washes, or from places in or near salt-formations, will not burn into good bricks. Before they receive heat sufficient to burn them into hard bricks they will fuse, warp, twist, and agglutinate together upon the surface, and in the arches of the kiln they "run" or melt quickly into unshapely masses of molten clay and form "burrs" or clinkers.

A very interesting, but unfortunately a very little understood, class of phenomena takes place when bricks made from the material which we have just considered, or those that contain but a small amount of it, are exposed to certain conditions. In the fall of the year, when heavy rains are prevalent, and at all seasons in damp positions, in old works as well as new, brick walls are often covered with a crystalline substance of a white fleecy appearance, suggestive of hoar-frost, and of a slightly acid flavor, which substance works its way through any ordinary coat of paint, and, as it absorbs the humidity of the atmosphere in efflorescing, it renders the walls damp on the surface, and carries off the paint in large patches, and the process is called by the English workmen "saltpetring," and sometimes in this country it is termed "whitewashing;" but it is, in fact, the production of saltpetre from the materials employed in the

construction of walls. The disagreeable effect it produces upon decorations, internal as well as external, should render the research of its cause highly interesting to the architect and the builder, and its action of greatly lessening durability of stone, as shown in the appearance of portions of the new Parliament Building in London, is such that the study of this singular chemical phenomenon should engage the attention of engineers to an equal extent. It is not always caused by the material of which the bricks are made, but sometimes by the sand, and often by the lime employed in making the mortar. Sea-sand, unless washed in fresh water and exposed for a period of not less than one year, always produces it.

Saltpetre is a nitrate of potassa, and although it is usually regarded as the sole cause of the appearances which have been described, it is far from being the only substance produced in the particular instances, as the nitrate of soda and the chloride of potassium are often met with in connection with saltpetre. But few chemists pay attention to the fact that nearly all limestones contain a certain quantity of soda and potassa; or at least in the analyses in chemical works no mention is made of their presence.

These saltpetre-exudations upon the facing-brick of buildings commonly appear in the form of unsightly whitish blotches on the surfaces. They are especially noticeable when such walls are constructed of an outer facing of fine pressed brick, and an inner or main wall of common brick. These blotches are due primarily to soluble alkalies and

alkaline earths present as impurities in the lower grade of clays from which building brick are made, and to the lime and magnesia from calcareous pebble deposits present in most of these clays, also to the lime and magnesia of the mortar with which the common brick are laid. The evil is further promoted by the manner of constructing the walls. These walls are commonly built with the facing of one width of a brick, the other part being of one or more lengths of bricks to form the thickness desired, the facing being of pressed brick. Such brick are commonly made of even, straight surfaces, and of suitable size to lay a close joint, while common brick are made roughly, of uneven surfaces, and laid with a wide, thick joint. In building these walls the facing-course of pressed brick is tied to the main wall of common brick by interlacing courses of rough brick, called "headers," which are made to penetrate and overlap the longitudinal rows or stretchers of the face-brick at every fifth course. This overlapping or interlacing of the respective courses of pressed and common brick serves well for tying or binding the wall together, but is highly objectionable on account of the intimate capillary contact of the facing-course of pressed brick with the common brick and with the mortar thereby inoculating and supplying the efflorescing germs to the face-brick. It is also the practice in constructing such walls to provide a mortar-paste for the facing course of brick, made of bone or marble dust combined with sand and a suitable coloring matter, such mortar being laid on sparingly, while the inner layers

or courses of common brick are laid with thick joints of common lime-mortar, the mortar being grouted into the joints and between the two contiguous courses of front and common brick, thus making the entire wall of pressed and common brick practically one body. The general practice is to wet or fully saturate the common brick with water just prior to laying them into the wall, to prevent the too rapid absorption of the water from the mortar by the brick, which causes the mortar to set too quickly. The substances of this wall-coating are sulphate of soda, sulphate of magnesia, and sulphate of lime, the first being commonly present in variable quantities in the clays, especially the drift-clays, being the result of igneous agencies and of chemical changes. In the second case, the magnesia in the brick-clay or magnesia in the lime of the mortar, is converted into the sulphate of magnesia either by the sulphurous fumes evolved in the process of burning in the kilns from iron pyrites present in the clays or the sulphurous fumes of the fuel, or by the absorption of sulphurous vapors of coal-gases from the general atmosphere. A like conversion takes place from the lime of the clay and mortar, which is converted into the sulphate of lime. These salts are readily dissolved by the water with which the common brick are saturated and the water of the mortar-paste, and are readily absorbed by the dry facing brick of the wall, evaporating through the pores of such brick and efflorescing upon the surface.

It has been proposed to obviate these defects by so placing tarred felt as to form a thin wall between the facing and

common bricks, and to make cavities in the top and bottom faces of the flat sides of the front bricks, and connect the pressed brick wall to the common brick backing by pieces of galvanized sheet-iron, punctured so as to roughen them, and laid between the flat joints of the bricks.

During the autumn of 1882 more of this efflorescence was to be seen upon buildings on both sides of the Atlantic than had appeared for many years; and old structures, such as the Pennsylvania Hospital, in Philadelphia, which were usually free from it, appeared to have developed as much of the deposit as those in the process of erection, as for instance the new Technical College at South Kensington, London, which was also covered in places with this objectionable eruption.

The question of what this efflorescence was and the cause was instigated by various scientific societies, the Academy of Natural Sciences, in Philadelphia, discussing it at length; and the substance of their decision was, that it was simply ordinary Epsom salts or sulphate of magnesia, which dissolved in the water passing over the bricks, and in evaporating left the deposit; the sulphurous acid, resulting from burning coal, combining in the presence of moisture with the magnesia in the mortar and forming the salts.

The earlier investigators believed that the production of the saltpetre was to be explained by the combination of the nitrogen present in the walls with the metallic oxides they might contain; that the nitrogen arose from a previous combination of the oxygen of the atmosphere with the azote supplied by the animal matter contained in the building materials.

This theory remained unquestioned until M. Longcamp proposed another, by which he sought the explanation of the production of the nitrogen, by supposing that the carbonates of lime and magnesia, taken in a proper degree of comminution, and properly wetted, could absorb air, condense it, and transform it into nitric acid in the course of time; causing it to enter into combination with the lime and magnesia, forming the nitrates of those two substances, and more readily enabling it to combine with the potassium, especially if it were present in the form of a carbonate.

But whatever theory may be adopted as to its origin, there appear to be certain conditions which facilitate the production of the saltpetre, viz: a degree of humidity, about equal to that of garden earth is very favorable; between 60° and 70° F. nitrification is the most abundant; at 32° it does not take place.

Clays containing a large amount of carbonaceous matter naturally mixed with it are very objectionable, as bricks when made from such clays will, when wetted in the wall, pass out soluble compounds which discolor the walls, whether they are painted or not, and plastering or stucco-work is discolored by them the same as when bricks which have once been used in the inside of a chimney flue and become blackened are re-used in new work.

It would be useless to attempt decorative work of any description upon brick walls, the materials of which contain a large amount of carbonaceous matter, or if the bricks be made from the alluvial mud of the embouchures of rivers,

as no possible precaution can prevent the entire destruction of the work.

No class of clay taken freshly from its bed is in a condition to be at once moulded into tempered bricks, even if it be of suitable composition, and it should first be exposed to the weather until its particles are disintegrated, when it can be kneaded into a mass of uniform consistency; this is best effected by the action of frost, the water diffused through the substance expanding by freezing and breaking in every direction.

The longer the exposure is continued, the more effectually is the clay reduced, and easily tempered and moulded, but the digging of clay in the autumn is not always attended to. To neglect it, however, is to run a great risk of having bricks unsound, as well as faulty in shape. Moistened or heated clay emits a peculiar smell, called argillaceous; the same term is also applied to the peculiar taste.

The argillaceous earths that are generally suitable for the manufacture of building bricks may be divided into three classes, viz:—

1. Loams, which are light sandy clays.

2. Pure clays, composed principally of alumina and silica.

3. Marls, which are earths that contain an unusually large proportion of lime.

It is not often that earths are found that are suitable for brick-making without mixing with something else, as the loams are usually so open, that in order to bind the earth, a

flux, in the nature of lime, has to be added; and if it happens that a loam requires no mixing, the difference in the working of adjacent strata in the same field is so great that in order to produce regularity in the size and color of the bricks, it is necessary to mix and temper two or three different kinds together, and for the same reason, and to prevent "checking," the pure clays also require mixing with some milder earth, loam, or sand.

In working marls, great trouble is experienced from skerry or impure limestone, which abounds in marl; but should a very small piece be allowed to remain in the clay, it is certain to destroy the brick into which it finds its way. To obviate these bad results, heavy iron rolls are used to pulverize the marls and the limestone found in them.

Clay is the only substance in the mineral kingdom that possesses plasticity, and if sand be in large proportion in loam, or if calcareous matters predominate in marl, so as to deprive either material of plasticity, it is no longer clay. Those clays which possess a high degree of plasticity are called long or fat; but when having but little plasticity, they are termed short, meagre, or lean; but, in the language of the brick-yard, the first is called "strong clay," and the latter "weak clay."

Mixed with considerable water, clays are more or less plastic, the degree of plasticity depending on their purity and peculiarities of composition; and, if possible, they should not be hauled into the brick-yard, dried by a scorching sun or drying wind, but in their moist and natural condition; for as they shrink and harden in drying, the labor of tempering

them into brick pug is largely increased, and then it is not so good, the plastic nature of the clay being less smooth and free than before.

Oxide of iron, lime, magnesia, potash, silica, bitumen, and fragments of rock are substances that impair the plasticity of clay, and they impress upon it certain characters that are of much importance to the manufacturer.

In England the process of brick-making is conducted somewhat differently from what it is in this country; and in the vicinity of London the principal supplies of brick-clays are obtained from the alluvial deposits lying above the London clay, the blue clay not being much used for brick-making. The material employed is a kind of gravelly loam, weak on the surface, and formerly gradually passing into either a strong clay or marl, or, as it is usually called, "malm," which is an earth suitable for making bricks, without any addition; but there is now but little natural malm to be had, as this class of clay is nearly exhausted. For making the best quality of bricks, which are called "malms," an artificial substitute is obtained by mixing together chalk and clay, previously reduced to a pulp in a wash-mill; this pulp is run off into shallow pits, where it remains until it has become of sufficient consistency for subsequent operations; but this process is resorted to for the best quality of bricks only, as the expense is too great for the commoner kinds.

The strong clay is not usually stony, and is generally worked without passing through the wash-mill, and the earth is mixed with chalk, reduced to the consistency of cream, which diminishes the contraction of the clay and

improves the gray color of the bricks; but the loams are usually so full of gravel that it is not possible to free them from stones without passing them through the wash-mill, and their texture is so open or loose, that a mixture of chalk is also necessary to bind the mass together, and to take up the excess of fusing silica in the process of burning.

Malming is not the only peculiarity of London brick-making, as the bricks are not burned in kilns as with us, but are "clamped;" and, to make this effective, it is necessary to mix the fuel with the brick-earth so that each brick will contain the fuel necessary for its own vitrification, which fuel is domestic ashes, and they are collected in large heaps and sifted. The siftings which are called "soil," are thoroughly incorporated with the brick-earth in the process of soiling and tempering.

The cinders, or, as they are called, "breeze," are used as fuel to ignite the lower tiers of bricks, from which the heat gradually spreads over the whole of the clamp, and no spaces are left between the bricks, which are closely stacked, that the heat to which they are exposed may be as uniform as possible.

The usual proportions of breeze for every one hundred thousand bricks are about twelve chaldrons of cinders or breeze to light the clamp, and about thirty-five chaldrons of the sifted ashes or soil mixed with the brick-earth.

This manner of burning bricks should not be confounded with the process called "clamping" so common, and practised largely both in this country and in some parts of Great Britain remote from London, which is usually a method of

burning bricks by placing them in a temporary kiln, the walls of which are generally built of "green" or unburned bricks. The name of clamp is also applied to a pile of bricks arranged for burning in the usual way, and encased with a thin wall of burned bricks and daubed over with mud to retain the heat.

The London brick-makers obtain their supply of sand from the bottom of the river Thames, near Woolwich, where it is raised into boats used for that purpose, and the bricks made by these brick-makers are of the weakest kind, being much inferior in quality to those made by their predecessors from the middle of the fifteenth to the middle of the eighteenth century. The Dutch clinkers, or paving bricks, have for many centuries been of the hardest kind and of a superior quality, and are manufactured principally at Moor, a village about two miles from Gouda, in South Holland, the principal brick-fields being on the banks of the river Yessel, from which the chief material is derived. This is no other than the slime deposited by the river on its shores and at the bottom. The slime of the Haarlem Meer is also extensively used for this purpose, and the men who collect this in boats have long poles with a cutting circle of iron at the end, also a bag net with which they lug up the slime; and the hard paving bricks used for their streets are made with a mixture of this slime and sand.

Building bricks are made extensively at Utrecht, in the province of the same name, from the brick-clay which abounds in the vicinity.

The manner of taking material for brick-making from the

bottoms of rivers and lakes with poles is not of modern origin, as will appear from the inscription which once stood upon the brick pyramid of Howara, ten leagues from Cairo, for Herodotus cites the following inscription as at one time standing upon it, the translation reading: "Do not undervalue me by comparing me with pyramids of stone, for I am better than they, as Jove exceeds the other deities. I am made of bricks from clay, brought up from the bottom of the lake, adhering to poles."

Clay of a superior quality for brick-making abounds in nearly every portion of Russia, and although brick-kilns are scattered all over the empire, the total production for 1880 was only about 750,000,000, which quantity would not more than supply the demands of the city of London in a busy building year.

By reason of the country's great wealth of timber the production and consumption of bricks are by no means in proportion to the population of Russia. Wooden buildings are the rule and those of brick construction the exception, nor do the disastrous and too constantly recurring fires, with their attendant train of misery and suffering, seem to have much effect in enlightening the people. But still some little progress is being made in the production of bricks in that country, as will appear from the increase in the number of works as well as greater rate of increase in value of products.

In 1867 the number of works was 2166; but in 1879 the number had increased 48.5 per cent., and was 3217, and employed 33,404 persons, which were about as many as were employed in any other two manufacturing indus-

tries of Russia combined, the great mass of population being of course engaged in agriculture.

The value of the brick product in 1867 was 4,622,667 rubles, and in 1869 it was 9,740,822 rubles, or an increase of 117 per cent. in value. Excellent china-clay or kaolin is found abundantly in the neighborhood of Gluchove in the government of Tchermigov.

In the northern part of France the clays are loamy and of a fair quality for brick-making; they are not deep, averaging only about two metres in depth, but they gradually improve in both quality and depth toward the southern portion. The Italian clays are of a superior quality for brick-making; they are naturally plastic, and require no sanding. Cuban and South American clays are generally poor both as regards strength and color.

There are a number of brick-kilns around Maracaibo for the manufacture of bricks and tiles. Maracaibo is the capital of the sovereign State of Zulia, one of the independent States composing the republic of Venezuela. The city has over 30,000 inhabitants, and is the residence of the President of Zulia.

The tiles are used both for roofing and flooring. There are also potteries for water-jars and earthen-ware pots; but the supply is not at all equal to the demand, and large numbers are continually imported, chiefly from France. Contrary to the usual run of South American clays, that in the vicinity of Maracaibo, and in fact for a great area around it, is pronounced to be of an excellent quality for brick-making.

At one time an attempt was made to produce the common class of porcelain ware, the materials for which were also found close by; but, after meeting with fair success, it was not continued; the lack of proper appliances, and the scarcity of anything like skilled labor in this branch of pottery, being the chief causes of the discontinuance of the manufacture.

Strabo, a Greek geographer, who died about A. D. 24, speaks of bricks made of an earth at Pitane, in the Troad, so light that they would easily float upon water; but, for many centuries, the art of making these bricks was completely lost, until re-discovered by Giovanni Fabroni in Tuscany in A. D. 1791, who, after a great number of trials, succeeded in making bricks that would float on water, and their strength was but little inferior to that of ordinary building bricks. They were not only remarkable for their extreme lightness, but also for their infusibility, and for being very poor conductors of heat, as they could be held by one end with the bare hand while the other was red hot.

Kützing found the material from which these bricks were made to contain immense numbers of microscopic silicious shells of infusoria, and similar earth has been discovered in France and Germany; but it is not, as has been supposed, the grayish substance that is sometimes found under peat bogs. Fabroni constructed the powder magazine of a wooden ship with these bricks, as an experiment, and the vessel being set on fire, sank without explosion of the powder. In A. D. 1832 Count de Nantes and Foninet, a French

engineer, used them in constructing powder magazines and other parts of ships, in order to lessen danger from fire.

Bricks of this kind have been used in Berlin for the construction of high-vaulted ceilings in churches, and in other positions where great lightness and fire-proof construction were desirable.

Pumice-stone detritus and certain varieties of volcanic tufa may readily be made into bricks of great lightness that will not only possess an average degree of strength, but which will also be poor conductors of heat, and clay could be added in order to bind the material together.

Southern Italy and some portions of the southwestern part of the United States, as also South America, are abundantly supplied with material from which these bricks could be very cheaply made.

In addition to the fireproofing of floors, ceilings, and roofs, another practical and important use to which these bricks could be put in modern architectural construction would be to use them in a hollow form in the place of frame partitions in the upper parts of buildings that it is often desirable to make fireproof, but which it is very often not possible to do from the plan of their construction. For instance, in cities, stores and other buildings are often erected of great height and width, the floor-space being sometimes unobstructed by columns in the principal story, which part may be fireproof, the upper portion being divided into smaller rooms, the partitions for which rest upon girders extending across the building and concealed in the floor. It would not be practicable to load these girders with heavy

ordinary brick-work, but bricks as light as those which have been described could be employed without material addition of weight. In this way the danger from fire could be greatly lessened, the rate of insurance, which is an important matter in expensive non-fireproof buildings, would on the structure be reduced to a small figure, and the rate on the stock which it might contain would also be favorably effected

(?) I. That which is rubbed or worn off, a geological term applied to material composed of small portions of a rock or deposit which have been detached & removed to a distance by the action of any abrading power. —

(?) II 2 A variety of volcanic rock, of an earthy texture, seldom very compact, & composed of an agglutination of fragments of scoriae & loose materials ejected from a volcano — called volcanic tuff, or volcanic tufa.

Calcareous Tufa, a porous rock deposited by calcareous waters on the exposure to the air & usually containing portions of plants & other organic substances incrusted in carbonate of lime. More solid form is called Travertine Tufa

CHAPTER III.

GENERAL REMARKS CONCERNING BRICKS; ENAMELLING BRICKS AND TILES; GLAZING EARTHENWARE, ETC.

SECTION I. GENERAL REMARKS CONCERNING BRICKS, THEIR SIZES, STRENGTH, AND OTHER QUALITIES.

BRICKS are commonly rectangular moulded blocks of clay, burned, and used for purposes of architectural and engineering construction; but the term is also applied to the moulded clay in its crude and unburned condition, in which state the bricks are said to be "green."

Adobes are bricks that have been dried by the heat of the sun and not burned with fire, and they are used mostly in countries of the east and south that are free from frost, in which the atmosphere is dry and warm.

An adobe may be reduced to a state of permanent plasticity by being kept mixed with water, and again become clay; but a brick which has been burned can never be again converted into that condition or substance.

A burned brick may be pulverized into a powder, in which condition it will be a cement, and when mixed with a small quantity of water will harden into a mass, or when mixed with a large quantity, it not being hydraulic, will settle at the bottom of the vessel and form into a substance resembling sand.

American building bricks vary in size in different localities, and often there is a diversity in the same location, the measurements for common bricks running from $7\frac{1}{2}$ to $9\frac{1}{4}$ inches in length, $3\frac{1}{2}$ to $4\frac{1}{2}$ in width, and from 2 to $2\frac{1}{4}$ in thickness, which variation is largely owing to the nature of the clay employed. Strong clays absorb a large quantity of water in tempering, and as the bricks made from this class of clays dry, they become much smaller, and when placed in the kiln and burned, their size is again greatly reduced by the action of heat, and bricks made from this kind of clay that were of a large size when moulded are often small and undersized when they come from the kiln. When this is so the strength of the bricks is not impaired, the principal objection to their use being that a larger number is required. Bricks made from weak clays absorb but little water in tempering, and do not shrink much in either drying or burning. Both hand-made and machine-made bricks are similarly affected in size from these causes.

A difference in the thickness of hand-made bricks is often caused by the wearing of the moulds, new moulds being generally used in the spring, which gradually wear thinner until in the autumn they have lost from one-eighth to three-sixteenths of an inch in depth, and bricks made in the fall of the year being correspondingly thinner than those made in the spring. The loss of one-eighth of an inch in the thickness of a brick may appear to be a very small affair; but it is not so insignificant as it may at first sight seem.

To lose one-eighth of an inch in one course of bricks, in its thickness, is to lose one inch in height in every eight

courses, or one foot in every twenty feet of elevation. In a medium-sized house, say 25 feet front by 60 feet deep, and 60 feet in height from foundation to finish, the walls being one brick and one-half in thickness, which, with chimneys and inside walls, would girt about 200 lineal feet, the loss would be about 600 cubic feet of brickwork, or over 10,000 bricks, as the walls would in that case require 18 bricks to the cubic foot.

The loss would also be in laying that quantity of extra bricks, and as the bricks and laying would cost in the neighborhood of, say $15 per thousand, a needless loss of about $150 would be inflicted either upon the owner or the builder, which would depend upon the circumstances governing the case.

This fact should be remembered, and engineers and architects having in charge large undertakings, requiring a long period for completion, and great quantities of bricks, should expressly require that all moulds that are subject to friction and liable to loss of depth, whether they be hand moulds, or machine moulds, shall be renewed not less than three times in each season. This should be done for the protection of their clients, if they should be furnishing the bricks, and if not, then for the good of the contractor; and also for the purpose of keeping the courses level and uniform throughout the work.

In the District of Columbia the authorities still enforce the ordinance of October 31, 1820, which requires that all moulds used for making plain bricks within the city of Washington shall be "stamped as correct by the sealer of weights and measures, and be $9\frac{1}{4}$ by $4\frac{5}{8}$, and $2\frac{1}{4}$ inches in the clear.

Stock bricks are to be made in moulds $2\frac{5}{8}$ deep in the clear." All persons who violate this law are subject to a fine of $25.

English bricks are larger than those commonly made in this country, being usually 9 inches long, $4\frac{1}{2}$ wide, and $2\frac{1}{4}$ thick, after burning, but they are not so strong, and are generally of an inferior quality.

In fact, those made by the London brick-makers are of the weakest sort, caused partly by the nature of the clay used, but principally from the habit of mixing ashes in large quantities with the clay; as the domestic ashes which they use contain a large quantity of unburned coal, which is reduced to ashes in the process of firing, leaving the brick very porous, greatly weakened, and generally shaky. This system is very undesirable, for two reasons; first, it is certainly injurious to the health of those who live in the neighborhood of the stacks, as refuse, frequently mixed with decomposed animal and vegetable matter, the contents of dust holes, is used in the process of burning; second, the matter of this kind which is sifted and mixed with the clay, pieces of bone and other substances of a similarly objectionable character, not being infrequent, is certain to yield an undesirable excrescence arising from nitrogenous substances, some of the evil effects of which have been described in the preceding chapter.

The most nauseating fumes often arise from the stacks of bricks made and burned in this manner, as the "soil" or finely sifted ashes used for mixing with the clay is offensive to the smell in either a dry or moist condition; the coarser material or "breeze" contains some coal, but also a large quantity of rags, bones, oyster-shell, hair, corks, etc., all of

which tend to make the immediate neighborhood of one of these clamps anything but a desirable place for a residence, especially in the hot close months of midsummer, which is the period during which the greater amount of this kind of brick burning is done. Day and night, for weeks and months, a great many people are compelled to breathe these sickening smells from this source, children pine away and die, the vitality of a great number of older persons is sapped away in the vicinity of these London clamps, and the English people, who never let an opportunity pass to find fault with our hygienic systems, and set themselves up for models for us to copy, and, in fact, they as much as say: "Look at us, follow us: we take good care of the body, we suffer nothing of a public character to undermine our health, while you do everything with such a rush that you do not take the time to pay any attention to the laws of health, and proper care of your bodies!"

Outside of the heart or thickly-settled portions of London, I do not believe that there is any one thing that is doing so much harm by poisoning or polluting the atmosphere as this extensive system of clamp burning.

Suits to suppress this nuisance are sometimes brought, in fact, are not uncommon; but those who institute such proceedings generally push them with so little vigor, and do not appear to have made any organized effort through the co-operation and help of their neighbors to suppress the system, that the courts do not seem to have had the cases at any time properly presented to them, and the defendant generally escapes by the payment of a most insignificant fine.

The habit of some of the brick-makers at Haverstraw, Croton Landing, and other places on the Hudson River, of mixing fine coal with the clay, has the same effect of weakening the bricks; and what little they gain in the time of burning is most dearly paid for in the greatly inferior quality of the stock.

The practice cannot be too severely condemned; clay is the only material of which bricks should be made; ashes or fine coal has no business to be mixed with it any more than fine wood, or any other combustible and weakening substance. The proper place to put that kind of material is in the arches of the kiln while the bricks are burning.

Pressed or front bricks are generally hand-made bricks that have been pressed when nearly dry in a hand press, and in their crude or green condition; they are called "gluts," and it is very essential that the clay of which they are made should be carefully selected and tempered. It should be free from gravel and other defective substances.

Machine-made bricks are sometimes re-pressed in a hand-press whilst damp, and make a second quality of pressed or front bricks, and generally sell for about one-half the price of the finer grades. Pressed bricks are usually slightly larger than common bricks, being generally made of weak clay, in order to give them a rich color; but the same causes that have been named above, as changing the size of common bricks, apply to this finer grade of bricks.

Great pains are taken with pressed bricks to preserve the corners and edges, which are called the "arrises," and the bricks are carefully taken from the kiln, the defective ones

being culled out, and the perfect ones assorted for a uniformity of color, the light-colored being hacked together, and the medium and dark-colored being also kept separate, all the culling, assorting, and hacking being usually done under a shed built for that purpose.

Machine-made bricks shrink less in drying, but more in burning, than hand-made bricks.

Burned common bricks are usually divided into three classes: arch, red, and salmon; and when made from the same class of clay, the salmon bricks are the largest in size and greatest in weight; the red bricks are next, and the arch bricks are the smallest in size and least in weight. The average weight of burned bricks is about 5 pounds; but individual weight depends upon and varies with the size, the amount of pressure to which the clay is subjected in tempering and moulding, the heat received in burning, the class, whether red, arch, or salmon, the kind, whether made by a dry-clay machine, a slush-machine, a damp-clay machine, or hand-made. The average weight of a cubic foot of brick is 110 pounds.

Tredgold gives the average specific gravity of brick as 18.41, and the cohesive force of a square inch as 275 pounds. He probably got hold of a very weak brick, for when the cohesive force is less than 400 pounds, the brick is not worth laying in any building where strength is a requisite.

A good quality of hard-burned bricks, especially when intended to be used in buildings of a public character, whether hand-made or machine-made, should withstand a pressure of not less than 7000 pounds to the square inch,

or about 450 tons to the square foot, which is more than good granite, and three times as much as good building stone will stand.

This may seem to be an extraordinary requirement, or it may be called an impossibility by some; but that it is not difficult to find bricks that will stand even this enormous pressure, and some a great deal more, will appear from the following tests made by direction of General M. C. Meigs, of the U. S. Army, who has been intrusted by Congress with the erection of a building for the use of the U. S. Pension Office, and which is now (1884) in course of construction at Washington, D. C. The tests were made at the U. S. Arsenal, Watertown, Mass., from samples of bricks supplied by the competing bidders of Washington, D. C., and the neighboring city of Baltimore, Md., by compression between cast-iron platforms, after the faces of the samples had been ground flat.

Below is given the pressure required to crush; the samples, for convenience being numbered from 1 to 12.

	Ultimate Strength. Total pounds Pressure.	Pressure per square inch.
No, 1. Red brick	324,500	9,540
" 2. Arch brick	255,200	7,600
" 3. Pressed brick . . .	231,000	6,470
" 4. Red brick	296,200	8,530
" 5. Arch brick	324,500	10,290
" 6. Pressed brick . . .	314,700	9,190
" 7. Red brick	211,000	6,050
" 8. Red brick	209,300	6,030
" 9. Red brick	232,000	6,700
" 10. Arch brick	203,700	6,800
" 11. Pressed brick . . .	210,000	5,960
" 12. Pressed brick . . .	249,000	6,750

For ordinary building purposes there is not the least doubt but that any of the bricks in the above list are more than amply strong; but for large and important government buildings, that are intended to go down to the coming centuries, there are some that it would not be good policy to use.

The contract was awarded for 9,000,000 common bricks, and 600,000 pressed bricks to the owners of samples Nos. 4, 5, and 6, which was a Washington Co., that manufacture with damp-clay machines. The following table will show the manner in which the bricks that were submitted as samples for the above tests were produced, and the class of clays of which they were made.

How produced, class of machines used in making, etc.	Condition of clay when moulded.	Kind of clay.
No. 1. Hand-made.	Tempered.	A mixture of strong and weak.
" 2. Dry-clay machine.	Dried.	Strong.
" 3. Hand-made "glut," pressed in a hand-press.	Tempered.	A mixture of weak and strong.
" 4. Damp-clay machine.	Damp.	Strong.
" 5. " "	"	"
" 6. " " repressed in a hand-press.	Wet.	"
" 7. Dry-clay machine.	Dried.	Weak and sandy.
" 8. " "	"	"
" 9. " "	"	"
" 10. " "	"	"
" 11. Dry-clay machine repressed in a hand-press.	Dampened.	"
" 12. Same as sample No. 3.		

In the above table where there is a mixture of clays, the one first named is the predominating one. It is useless for me to give other tests that have been made either in this country or in Europe, for no bricks have ever before made so good a showing; but that is no reason why they should not. Advancement is necessary in the strength of bricks made for the New York and London markets, as there has been a great decline in this regard for some years past.

Clays that will make good hand-made bricks will always make equally as good stock, if not better, when tempered into pug and moulded by machinery. When it is intended to mould the clay into bricks without being tempered, by what are termed dry-clay machines, great caution and discretion should be used both in selecting a machine and also in making the stock.

There is no such thing as dry clay, for when all the water, mechanical and chemical, has been driven out of clay, by any means, the substance is not clay but something else. The machines which are termed dry-clay machines seldom if ever make satisfactory bricks. The difference between dry-clay machines and damp-clay machines is that the first uses clay that has been dried by the sun or wind, and the other works it in its moist condition, as it comes from the bank. The latter is preferable for all reasons, the nearer clay approaches a plastic condition when moulded into bricks the better will be the stock produced, for when the clay is dried before being moulded, it is impossible to produce a strong brick, the particles of clay will not agglutinate under pressure, and in the kiln the heat will pass through the brick, and not be

so effective as in a damper and denser made brick. It will require 25 per cent. more fuel and longer time to burn the dried clay brick than the one made with damp clay. This is a fact that is well known to manufacturers of hand-made bricks, only in a different form, They are only too fully aware that bricks made in the summer, and carried unburned in the sheds through the autumn and winter, will be much drier in the spring; but will require a greater quantity of fuel than if they had been burned within a few weeks after making.

For all machines that are intended to make bricks without tempering, the clay should be taken directly from the bank finely pulverized and fed to the moulds in as moist and natural a condition as it is possible to work it. All bricks made by this class of machines will have small cracks on the faces caused by the outer surfaces drying quickly, and also from the air contained in the clay expanding during burning.

This is not a great drawback to the strength of the bricks for building purposes, unless the cracks are large and extend into the body. When it is intended to use bricks made by any of this class of machines for sewers, culverts, tunnels, wells, or other places where there is an unusual amount of dampness, only those that have been thoroughly burned should be allowed, under any circumstances, to go into the work.

For aqueducts, reservoirs, pavements, and all of the above class of work, it is much better to use hard-burned hand-made, or tempered clay machine-made bricks, when it is possible to obtain them.

All tempered clay bricks are denser or closer in the in-

terior than on the outer surface, while bricks made from dry clays are just the reverse. In the latter process a slight moisture is developed on the surface under pressure which forms a smooth, thin veneering on the faces of the bricks; and when this wears away the remainder of the brick soon disintegrates under the influence of dampness, acids, and gases.

Section II. Enamelling and Glazing Bricks and Tiles having plain and uneven surfaces, Earthenware, etc.

For damp and exposed walls of buildings, bricks have sometimes been glazed or rendered water proof by a composition which gives them a vitreous surface, and this is done by treating the faces with a flux which meets the silex of the brick; or it may be applied in solution, the liquid being afterward expelled by heat.

Resinous compounds have also been used to render the surface non-absorbent, and bricks have also been treated with soluble silicate of soda, which has been decomposed, leaving the insoluble silex in the pores of the brick. Cheap pigments may be added to the glazing compounds which will give an ornamental appearance at a moderate cost.

In some cases, when the bricks are to be employed for sanitary purposes, a glass enamel is used, composed of 130 parts of flint-glass powdered, $20\frac{1}{2}$ parts of carbonate of soda, and 12 parts of boracic acid; the surface of the brick being first washed with water containing a small amount of glue, the preparation then applied in solution and fluxed in an oven.

Ornamental bricks are now made in many designs and of a great variety of colors, which are usually produced by the employment of metallic oxides and, sometimes, ochreous metallic earths, oxides of lead, platinum, chromium, and uranium are used for very fine colors, and the work is done not in actual colors but in materials which will assume certain colors under the action of fire. Porcelain and glass enamelling are also often used for bricks that are largely employed for internal as well as external decorative building.

The facility with which colors might be introduced into vitreous compounds or applied to them, and become fixed by subsequent fusion or baking, made the practice in early times exceedingly popular, and even in the middle ages it attained a higher rank than it now holds as one of the fine arts.

The colors now mostly used for architectural decorations in chromatic brick-work are the same, with the exception of buff and brown, as those employed by the ancient Egyptians, viz: red, yellow, blue, sometimes green, and white and black, the modern colors being produced by the employment of the following oxides of the metals named.

Red: Iron, iron sulphate, copper (oxidule), ochre.

Yellow: Antimony, with potash or sulphide, titanium, chromate of lead, chromate of barytes. Zinc brightens yellow.

Buff: The same ingredients as for yellow with the addition of iron, sepia, sienna, ochre, umber, earths.

Blue: Cobalt, carbonate of cobalt, smalt or silicate of cobalt. Zinc brightens blue.

Green: Copper, with or without antimony, chrome with cobalt.

White: White clay with finely powdered soap-stone and 5 per cent. tin oxide.

Black: Iron, manganese, uranium, iridium.

Brown: iron, chromate of iron, manganese, with or without cobalt, ochre, and hammer cinder.

For encaustic colors the coloring oxides are introduced in quantities usually of 5 to 10 per cent. They act as fluxes, and the composition of the body must be altered in some cases to counteract this.

To color under the glaze, the burned brick is dipped into a slip of colored clay, formed usually of one part colored glass, ground, and two parts of clay; the latter causing the adhesion of the slip, and the brick is either then fired, or after being allowed to dry, it is coated with a transparent glaze and then fired; but the brick should be heated before applying the glaze, in order that all oily substances may be removed.

When the colors are in the glaze, the brick is dipped in a transparent colored glaze usually formed, besides the coloring oxides of:—

Oxide of lead	from 40 to 50	per cent.
Silicious sand	" 30 to 40	"
Salt	" 0 to 12	"

All enamels and glazes for ornamental bricks are usually applied to the one face or head which will be exposed after laying in the wall, except those intended to be used for corners and reveals of window and door-jambs, which have one

face and head treated, and are termed "rights" and "lefts" when they are so moulded or ornamented that they cannot be used for any corner.

In addition to the colors which have been given for highly ornamental bricks there are others that it might be desirable to employ, especially for interior and expensive decorative purposes; they are turquoise, bronze green, olive green, violet, purple, orange, carmine, pink, gray, and indigo.

Turquoise: Copper with soda; cobalt with zinc and soda phosphate.

Bronze Green: Nickel, zinc, and its carbonates will brighten all greens.

Olive Green: Nickel with cobalt.

Violet: Iron, manganese with soda.

Purple: Chloride of gold with tin chloride of silver.

Orange: Uranium; sulphide of antimony with iron.

Carmine: Chloride of silver.

Pink: Iron and chromate with potash.

Gray: Iron, cobalt, iridium, platinum, titanium.

Indigo: Compound of violet and blue.

Mr. Decius W. Clark, of Philadelphia, Pa., claims to have discovered a true enamel, suitable for building brick and other articles produced from clay, and also for iron and other metallic articles, which enamel is capable of a great variety of colors, able to resist heat, cold, or moisture, and any tendency to oxidization or decay.

When it is desired to produce by Mr. Clark's process an enamel of a white color, use eighty parts, by weight, of feld-spar; seventy parts of flint or quartz; sixty-five parts of

paris-white; fifty parts of oxide of zinc; fifty parts of boracic acid; twelve parts of kaolin or china-clay, or their chemical equivalents.

For the various colors enumerated below, use—

For black, eighty-five parts, by weight, of feldspar; seventy parts of flint or quartz; sixty-five parts of paris-white; fifty parts of oxide of zinc; fifty-four parts of boracic acid; twelve parts of kaolin or china-clay; two parts of black oxide of manganese; one part of black oxide of cobalt.

For blue, eighty parts, by weight, of feldspar; seventy parts of flint or quartz; sixty-five parts of paris-white; fifty-two parts of boracic acid; fifty parts of oxide of zinc; twelve parts of kaolin or china-clay; two parts of black oxide of cobalt.

For yellow, eighty parts, by weight, of feldspar; seventy parts of flint or quartz; sixty-five parts of paris-white; fifty-two parts of boracic acid; fifty parts of oxide of zinc; twelve parts of kaolin or china-clay; two parts of oxide of uranium.

For drab, eighty parts, by weight, of feldspar; seventy parts of flint or quartz; sixty-five parts of paris-white; fifty-five parts of boracic acid; fifty parts of oxide of zinc; twelve parts of kaolin or china-clay; six parts of Brandon mineral paint; one part of potters' blue.

For green, eighty parts, by weight, of feldspar; seventy parts of flint or quartz; sixty-five parts of paris-white; fifty-two and one-half parts of boracic acid; fifty parts of oxide of zinc; sixteen parts of kaolin or china-clay; two and one-half parts of oxide of copper.

For red, eighty parts, by weight, of feldspar; seventy parts of flint or quartz; sixty-five parts of paris-white; fifty

two and one-half parts of boracic acid; fifty parts of oxide of zinc; eight parts of kaolin or china-clay; four parts of lime; two and one-half parts of suboxide of copper.

For brownstone, red sandstone, and various other colors, variable proportions of these several mixtures may be used, as desired, and the ingredients may also be varied.

It is to be observed that the various proportions of the different ingredients may be slightly changed, as experience may dictate, in consequence of the variety in the constituent parts of various clays, some clays having more oxide of iron and more lime than other clays.

The method of using these various elements to produce the desired results is to combine all the several ingredients for any special color together in a crucible or retort and calcine them together, not separately, if the best results are desired. Then reduce the mass, in a mill or under the muller or pestle, with water to about the consistency of cream, or to such a degree as to be easily and smoothly spread over the surface to be treated. The articles are then coated, either by brushes or immersion, placed four in each sagger, and then raised to a sufficient temperature in a glazing kiln to fuse the enamelling compound.

Another improvement by Mr. Clark relates to a building-brick having an enamelled surface or surfaces of any desired color.

In preparing this enamelling compound—take about one hundred and fifty parts of fluor-spar, about sixty parts of paris-white, about fifty parts of lime, about fifty parts of oxide of tin or its equivalent, and about fifty parts of kaolin.

These ingredients pulverize and triturate to an impalpable powder, reducing the whole to a homogeneous mass, which place in a crucible or other suitable vessel and calcine. After this calcined mass is cooled off it is again reduced to a powder by the pulverizing process. Sufficient water is then added, and the whole triturated, so that it will form an enamelling compound of about the consistency of cream. In this compound immerse that portion of the brick desired to be enamelled, and then subject it to a sufficient temperature to fuse the enamelling material on its surface.

When it is desired to make a brick having a black enamelled surface, add the black oxide of cobalt, black oxide of manganese, and umber to the hereinbefore-named ingredients prior to the pulverizing and calcining process. For a blue enamelled surface, the black oxide of cobalt is used in like manner. For a green enamelled surface, suboxide of copper is used. For a red enamelled surface, suboxide of copper and red oxide of iron are used. For drab enamelled surface, mineral paint known as the "Brandon mineral paint," manufactured at Brandon, in the State of Vermont. For bronze marble, carmine, and other shades and tints formed by a combination of the above, the ingredients are pulverized and formed into a homogeneous mass, and a suitable quantity of it is added to the ingredients forming the enamelling compound to produce the shade or tint desired.

With this enamelling compound the surface of the ordinary red front brick may be enamelled, and any desired shade or tint given to the enamelled surface—a result not

successfully accomplished prior to the date of this invention. The patentee is enabled, therefore, to produce, at a comparatively low cost, building brick having an enamelled and ornamental surface which is unaffected by the action of heat, frost, or other atmospheric conditions.

The ordinary front brick employed is made of any of the clays commonly used in the manufacture of such brick, and burned in the usual manner.

The surface of the brick to be enamelled should be smooth. To this end they should preferably be pressed; but the surface to be enamelled should be free from sand, or otherwise the enamel will not adhere.

It being obvious that the enamelled brick will only be used for forming fronts and other parts of the building requiring a fine finish and ornamentation, brick having a rough uneven surface, or porous, will not answer, for the enamelled surface will be uneven in one case, and full of small indentations in the other.

Mr. John D. Logan, of Philadelphia, Pa., has invented a process, the object of which is also to treat bricks or building-blocks to solutions or coloring-matter and glaze, whereby their value for building purposes will be enhanced, and a structure be ornamented by allowing a choice of colors and shades at the will of the builder.

In carrying out the invention, he employs the following formula to form the solution, which, for convenience, we will designate the "white body, or slip:" blue clay, ninety-nine pounds; china-clay, three hundred and twenty-one pounds; spar, three hundred and fifteen pounds; flint, forty-

two pounds; bone (calcined and ground), three hundred and fifty-four pounds. These ingredients are mixed in a sufficient quantity of water, which will give a consistence to the solution that will allow it to be passed through a bolting-cloth of seventy meshes to the square inch, after which the solution is allowed to settle, and the water poured off until the residuum will weigh, approximately, twenty-four ounces to the pint. The bricks are dipped or immersed in this solution and allowed to dry, after which they are treated with a glaze or enamelling solution, and again dried. The glaze solution is prepared as follows: spar, ninety pounds; Paris white, eighty pounds; china-clay, twenty pounds; borax, sixty pounds; soda-ash, sixty pounds; flint, forty pounds. These mix and calcine in a gloss-kiln. Of this mixture, take two hundred pounds; spar, seventy pounds; flint, forty pounds; white lead, fifty pounds. Grind together wet, and with water form a solution which will pass through a bolting cloth of eighty meshes to the square inch. After treating with this solution, the bricks are placed in saggers (?1) and set in a kiln and burned until the glaze flows.

The white body may be changed to a green slip by taking two quarts of the same, and adding thereto two ounces of black oxide of copper, and one ounce of blue calx; to a blue slip, by taking four quarts of the same, and adding four ounces of blue calx (?2); to a drab slip by taking four quarts of the same, and adding two ounces of black oxide of manganese, and one ounce of blue calx. To make a black slip, take one hundred pounds of brick-clay, and with water form a solution which will pass through a bolting-cloth of seventy

1 Saggers – cylindrical or oval cases of [illegible] clay, in which fine stoneware is enclosed while [illegible] in the [illegible]

2 Calx – quicklime was applied by the alchemists [illegible] products of combustion [illegible] oxidation [illegible]

meshes to the square inch, then add twenty-five pounds of carbonate of iron, and thirteen pounds of black oxide of manganese, and reduce the whole to a liquid weighing twenty-four ounces to the pint.

The blue calx, before mentioned, is formed as follows: Take oxide of cobalt, ten pounds; spar, thirty pounds; oxide of zinc, four pounds; nitrate of soda, two and one-half pounds. Mix and calcine in a gloss-kiln, and grind wet to a solution of thirty-two ounces to the pint.

Ornamenting Bricks and Tiles of Uneven Surface, with Metallic or Vitreous Colors.

Mr. James C. Anderson, of Chicago, Ill., has lately put into operation an invention which relates to the ornamentation of bricks and tiles of uneven surfaces; and it consists in applying metallic or vitreous colors to them while being formed in the mould. It is different from the manner in which plain surfaces are decorated, and it is accomplished by causing the ornament to be imbedded in the face of the brick or tile, the same having been previously printed or stencilled in metallic or vitrifiable colors on paper or inflammable material, which is placed in the mould, with the ornamental surface next to the clay. The clay is then compressed into a brick or tile, the ornament becoming imbedded in the clay, and the paper adhering to the article until consumed by the fires of the kiln in burning the brick or tile. In this instance, the object is to ornament in vitrifiable or metallic colors bricks or tiles of uneven surfaces; or, rather, with raised or depressed surfaces, and in which such raised or depressed portions form

ornaments in themselves. As an example, suppose a brick or tile is to be provided with a series of concentric circles in relief, and that it is desired to beautify such circles with colors different from the body of the brick. This may be done by making the circles of different colors, or combining various colors in one circle, or by wreaths of flowers, etc.; and in accomplishing this, it is necessary to form the desired design or pattern in the matrix or bottom of the mould, or in the plunger or plungers which compress the material into shape. The same design is then printed, stencilled, or otherwise placed on paper or other suitable material, in metallic or other vitrifiable colors, and in such manner as will produce the most desirable effect. This pattern or print is now placed in the mould, with the color next to the clay, care being exercised to have the ornaments on the paper to match with the depressions in the mould. This can be best accomplished by cutting the paper the same size as the mould, and having the designs on the paper in the same relative position in regard to the face of the brick as the design on the matrix or plunger, or, rather, have the design on the paper or other material register with the pattern in the mould or matrix. Pressure is now applied, which forms the brick or tile, and at the same time causes the coloring matter to be imbedded or to adhere to the brick or tile, together with the paper. The article thus formed is now subjected to the fires of the kiln, and in this burning operation the paper is destroyed, and the colors burned in or permanently fixed to the brick or tile. We have given this illustration of a brick with concentric circles in relief or in depression

to more readily explain and simplify the invention ; but it is obvious that designs without number—geometrical designs, designs of birds, beasts, reptiles, flowers, and landscapes—can be produced in the same manner.

The plain portions of the brick may be collected or ornamented in any desirable manner, and the portions in relief be of the natural color of the clay. Metallic foil, which will withstand the fires of the furnace may be placed on the brick in the same manner, and with good results.

For the better protection of the ornament, and to prevent the same from becoming injured in the firing, there may be formed, on the opposite side of the brick or tile cavities, for the reception of the designs in relief on the opposite side, so that by piling the bricks in the kiln back to face, and allowing the relief designs to be pocketed into these cavities the ornament will be fully protected from dust and smoke, and all danger of mashing, breaking, or injuring the relief design obviated.

Ornamentation of Bricks, Tiles, and Building-blocks having Plain or Uniform Surfaces.

This process, which is by the same inventor as the one above described for ornamenting clay bodies with uneven surfaces, relates to the ornamentation of bricks, tiles, building-blocks, and other bodies of clay having uniform or plain surfaces ; and it consists in placing the ornament of whatever kind between the faces of the brick or tile as they are being piled or set in the kiln for burning, so that in the

burning of the articles the ornament will be fixed and become a part thereof.

In carrying out this invention the inventor spreads or prints the coloring matter, of any desired color or combination of colors, on paper or other suitable material, which will be consumed in the firing and burning of the brick or tile, and leave the color or ornament in place and fixed on the face of the article. The bricks or tiles, having been formed in the usual manner, are laid up or set in the kiln face to face upon their edges, in stretching-courses of two or three bricks high, with fire spaces between the courses, and then like heading or cross courses are laid, as is usual in setting fine pressed brick in the kilns. The ornaments, of whatever kind, are placed between the bricks and in contact with the face, sides, or edges to be ornamented. When the kiln is properly filled the firing takes place (a down-draft kiln being preferred, such as that shown in Chapter IV., Section VI.) and as the bricks are slightly softened by the evaporation of the water from the stock, or in the act of driving off what we have previously termed the "water-smoke," the bricks being set one upon the other, the combined weight of the mass above is utilized in compressing the ornament, and the bricks will settle down and embed the ornament therein. In the process of firing, the bricks or tiles pass through two softening periods—the one just mentioned, the other when they have reached a degree of heat when semi-vitrification and shrinkage take place. Before reaching the latter point the paper or other material on which the ornament has been placed is consumed, leav-

ing the ornament impressed and permanently fixed on the brick or tile.

Leaves, plants, etc., can be used to receive the body-color, or the leaves, plants, etc., may be saturated or permeated with the coloring-matter in a liquid or semi-liquid state, the pores and surface being filled or covered with the desired color to represent the leaf, plant, etc., when burned, as it is in a state of nature, or in varied and different colors. It will be understood, however, that by this process it is possible to inlay or ornament with gold-leaf, silver-leaf, or with any thin ornament or metallic colors not affected by the heat, but such as will be fixed or vitrified in the burning.

The paper used on which to print or paint the design is by preference what is known as "unsized" paper; but it is not necessary to be confined to paper of any kind or to leaves, as it is obvious that sheets of gelatine, wax, and the like may be employed for this purpose.

Nor is it necessary to be confined to any particular form of ornament, as it is obvious that geometrical figures may be so arranged that a series of bricks or tiles of a certain series will form the design when placed in position, and that ivy-vines and other climbing plants may be brought out with good effect on the wall or floor of a building. Figures, letters, and, in fact, a vast variety of designs, can thus be produced at a comparatively slight cost.

Enamelling Fine Wares.

Two kinds of glazes are used in Staffordshire, England, for the higher grades of pottery.

The following is the composition of a glaze intended to cover all kinds of figures printed in metallic colors: 26 parts of white feldspar are fritted with 6 parts of soda, 2 of nitre, and 1 of borax; to 20 pounds of this frit, 26 parts of feldspar, 20 of white lead, 6 of ground flints, 4 of chalk, 1 of oxide of tin, and a small quantity of oxide of cobalt, to destroy the brown cast and to induce a faint azure tint, are added.

The following may also be used: frit together 20 parts of flint-glass, 6 of flints, 2 of nitre, and 1 of borax; add to 12 parts of that frit 40 parts of white-lead, 36 of feldspar, 8 of flints, and 6 of flint-glass; then grind the whole together into a uniform cream-consistenced paste.

As to the ware which is to be painted, it is covered with a glaze composed of 13 parts of the printing-color frit, to which are added 50 parts of red-lead, 40 of white-lead, and 12 of flint; the whole having been ground together.

If fired in saggers, in order that they may not absorb any of the vitrifying matter, they are themselves coated with a glaze composed of 13 parts of common salt and 30 parts of potash, simply dissolved in water and brushed over them.

In fine enamelling, ground-laying is the first process; in operating on all designs to which it is applied, it requires lightness and delicacy of hand principally, and is extremely simple.

A coat of boiled oil adapted to the purpose being laid upon the ware with a hair pencil, and afterwards levelled, or as it is termed technically "bossed," until the surface is

perfectly uniform; as the deposit of more oil on one part than on another would cause a proportionate increase of color to adhere, and consequently produce a deepening or variation of the tint.

The "bossing" having been properly done, the color in a state of fine powder is dusted on the oiled surface with fine cotton-waste; a sufficient quantity very readily attaches itself, and the superfluity is cleared off by the same medium.

If it be requisite to preserve a panel ornament, or any object of the ground color, an additional process is necessary, termed "stencilling." The stencil, generally a mixture of rose-pink, sugar, and water, is laid on in the form desired with a pencil, so as to entirely protect that portion of the surface of the ware or tile from the oil, and the process of "grounding," as described above, ensues. It is then dried in an oven to harden the color and dispel the oil, and then immersed in water, which penetrates to the stencil, and, softening the sugar, is then easily washed off, carrying with it any portion of color or oil that may be upon it, and leaving the ware free, and perfectly clean.

When great depth of color is necessary, the colors are repeated several times, when only a lighter increase of shade is required they are repeated a less number of times.

Bandages are generally, and should be at times, worn over the mouths of the "ground-layers," as the inhaling of the color-dust is very injurious.

"Bossing" is the term applied to the process by which the level surfaces of the various colors, extensively introduced upon decorated porcelain, are effected; tiles are sometimes so

treated. The "boss" is made of soft and very pliant leather.

The process of gilding is as follows: the gold, which is prepared with quicksilver and flux, when ready for use, appears a black dust; it is used with turpentine and oil, similar to the enamel colors, and, like them, worked with the ordinary camel's-hair pencil. It flows very freely, and is equally adapted for producing broad massive bands and grounds, or the finest details of the most elaborate designs.

To avoid the difficulty and expense of drawing the pattern upon every piece of a service, if it be porcelain ware, or upon every tile, if of similar design, a "pounce" is used, and the outline dusted through with charcoal, which secures uniformity of size and shape.

Firing restores the gold to its proper tint, which first assumes the character of "dead gold;" sometimes it is left so; the process of making it brilliant, afterwards applied, is termed "burnishing."

The glaze-kiln is usually smaller than the biscuit-kiln, and contains no more than forty or forty-five bungs or columns, each composed of sixteen or seventeen saggers.

Those of the first bung rest upon round tiles, and are well luted or held together by a very finely ground fire-clay of only moderate cohesion; those of the second bung are supported by an additional tile.

The lower saggers contain the cream-colored articles, of which the glaze is softer than that applied to the blue painted ware, this being always so in the tile and brick-glazing-kilns, as well as in porcelain-kilns, and the blue

enamelled ware is placed in the intervals between the furnaces, and in the uppermost saggers of the columns. The bottom of the kiln, when the glazed ware is not baked, is occupied by printed biscuit-ware; sometimes it is also used in tile-glazing kilns for hardening the color "grounded" on the ware. The glazing of this class of ware is a matter of experience, a full knowledge of the character of the clay forming the body of the tile or ware is necessary, as well as a knowledge of the age and behavior of the kiln under fire, and other peculiarities.

The pyrometric balls employed must be fully understood in all their changes by the glazer, and he must carefully follow the heat from the low temperature, at which enamel baking commences, through its progressively increasing stages.

When the melting point of the glaze is reached, the heat must be steadily maintained, and the mouths of the furnaces carefully watched lest the heat should be suffered to fall.

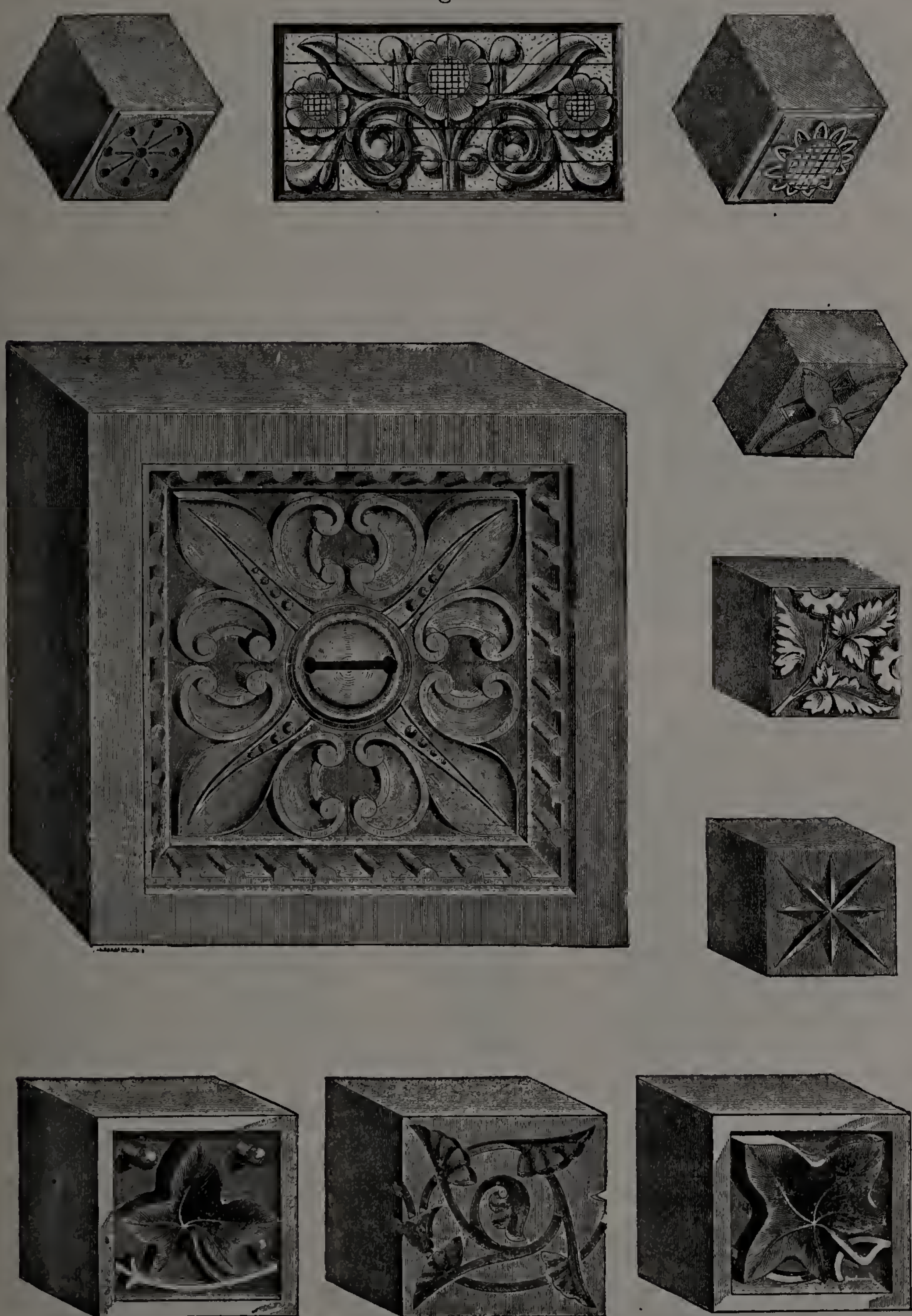
The firing is usually continued for fourteen hours, and then gradually lowered by slight additions of fuel, after which six or eight hours, or longer if the time can be spared, are allowed the kiln to cool.

There are various ways of glazing ordinary tiles, sometimes a glazing compound is applied within the saggers into which the articles are placed for the first firing, and the glazing done without any other burning being necessary.

Or the glaze may be mixed with the earthy matter of which the tiles are formed, and be produced as an encaustic glaze in the first burning.

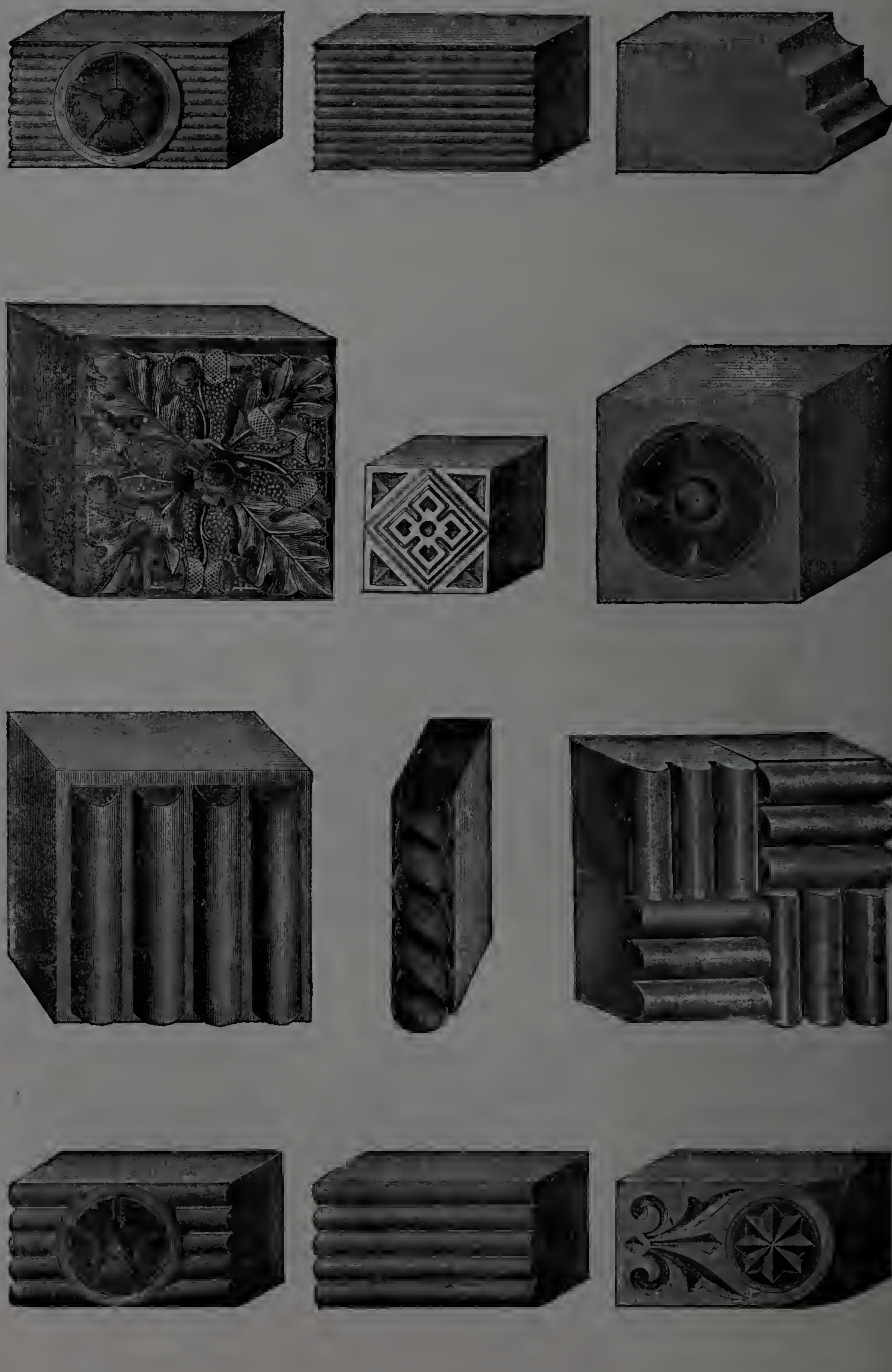
The designs of ornamental bricks shown in Figs. 1 and 2 are one-eighth full size and are a few of the numerous ones

Fig. 1.



produced by the Peerless Brick Company of Philadelphia, who are justly celebrated for the high character of their

Fig. 2.



artistic executions in clay, which have done so much to add to the beauty and variety of architectural constructions, by breaking up plain brick surfaces and substituting relief and intaglio ornamentation. Such designs as those shown in Figs. 1 and 2 may be produced in such encaustic colors as red, brown, buff, etc., or they may be enamelled in any desired hue.

When a person builds a dwelling for his own use he makes an exact picture of his tastes, and exhibits the degree of his refinement and cultivation, whether the structure be costly or not, the same as he does in his dress and personal appearance, for plain people build, dress, and live plainly, and as we have had a majority of this kind in the times gone by, we now possess their pictures in the plain, unassuming buildings which survive them. But that period is now rapidly passing away, and attractive designs in architectural constructions are to be seen on all sides, in suburbs and country as well as in towns and cities, and now we are, in many instances, combining elegance of appearance with solidity of construction.

It is not at all necessary to make a house expensive in order to make it attractive, for some of the most costly structures are the least so.

Pleasing ornamentations in burned clay can now be purchased so cheaply that a person who builds of brick without them generally does so from lack of all desire for these embellishments of the exterior of his home.

The ornamental bricks shown on pages 93 and 94 are made from tempered clay, and are moulded and pressed by

hand, great care being observed to have the clay free from stones and small gravels, and also in the handling, rubbing or sanding and drying of the green bricks, for if the drying be done too rapidly they will have small cracks over their surface, which are great objections in the eyes of buyers, and in the kiln the bricks are carried along gently at first in the burning or firing in order not to "crush" or "squeeze" them, as they become soft while the steam or "water smoke" is being driven off.

Earthenware Glazes.

Bricks are sometimes glazed in a manner similar to earthenware, in which case the glaze is applied to the surface of the brick and is of a nature much more fusible than the body. This glaze is transparent, and should be hard enough not to be easily scratched with any sharp steel instrument.

Alumina, in small proportion, and silica, in large proportion (derived from kaolin), flint, chalk, feldspar, saltpetre, and alkalies are variously used, white lead being the base of this colorless, transparent glass-glaze. The iron oxide is added, and the glaze is burnt to a glass; this glass is finely pulverized or ground; and after being tempered with water, the brick, or the earthenware in the biscuit state, is dipped into it, and then burnt a second time, at a low heat of 12° to 30° Wedgewood's pyrometer, during which the glaze is fastened to the brick or earthenware, as the case may be.

If patterns are printed on earthenware, they are always pressed upon the biscuit before the ware is dipped into the glaze. Borax is used to intensify the colors, and to get rid

of an undesirable yellow tinge, and in order to produce a bluish hue, a very small quantity, less than one thousandth, of smalt is added. The following glaze is given by Cowper, and to form which Cornish stone, granite, borax, and gypsum are used.

Silica	43.66
Alumina and iron oxide	9.56
Borax	20.08
Carbonate of lead	15.19
Chalk	10.88
Calcium	0.52

A cheap salt glaze, applied in a manner similar to that for stoneware, can also be given to bricks. The salt glaze is applied when the stoneware has reached nearly its highest temperature in the kiln. For bricks the fires should be properly managed, and at the right temperature in a closed kiln or oven common salt is thrown uniformly through holes at the top of the kilns; small, light scoop shovels are best for this purpose. The amount of salt necessary for a moderate sized oven is one hundred and fifty to one hundred and sixty pounds.

After about one-half the quantity of salt has been thrown into the oven, the fire is momentarily increased, then reduced, and a few of the specimens examined. The remainder of the salt is then thrown in, part at the top, and part regularly over the top of the fire. A few holes in the doors, not exposed to the wind, are allowed to go unplugged for a few hours; but all other openings are carefully closed and plastered around with mud, and the oven allowed to cool off for

five days. When the salt is thrown into the oven, and quickly followed by oxide of lead, a much more brilliant glaze is the result.

The volatilized salt is quickly decomposed by the steam in the smoke into chlorhydric acid and soda, which forms a veneering, or thin film of soda glass on the surface of the bricks or ware, by uniting with the silica of the clay. Sandy clays become the most lustrous, and receive the glaze best.

SECTION III. BLUE BRICKS.

Blue bricks is the name given to a material which, for some purposes, has no equal, being for some requirements much superior to the best quality of stone.

In England, and in many parts of the Netherlands, it is most highly esteemed for road and stable pavements, copings, channel courses, and for solid walls, especially hydraulic constructions.

The bricks resemble cast-iron for hardness, but are much superior to it for durability, being incapable of being eaten away by oxidizing.

Clays which contain the greatest number of elements that are soluble in chlorhydric acid are the best for the production of these bricks, and for terro-metallic ware in general.

Natural clay, containing oxide of iron in abundance, and sometimes highly impregnated with lime, and which is consequently much more fusible than ordinary brick-clay, is the material mostly used.

In Staffordshire, the clay used is a ferruginous material, which is easily fused at a china-biscuit heat.

When natural materials, properly combined, are not possible to get, iron and lime, in the shape of slag ground, are usually mixed with fat clay; fine coke dust, chalk dust, and mill cinder are used in England.

Pugging, as well as the moulding of this class of bricks, must be done by machinery.

The most economical, as well as effective, kilns for the burning of this kind of bricks, and for all classes of terro-metallic ware, are those constructed on the annular system, as the firing is to a high vitrifying temperature, and the cost of fuel is a most expensive item, unless kilns on the continuous plan are employed. The blue color does not impregnate the whole body of the Staffordshire brick, as for terro-metallic ware, but penetrates only to about one-eighth of an inch from the surface.

The color is obtained by continually submitting the stock or ware, when at a high degree of heat, to a reducing atmosphere of smoke, thereby converting the red peroxide of iron into protoxide; sulphur greatly assists this process. The salts of the protoxide of iron are all bluish and greenish. The same clay or material may be made to yield a red brick, blue brick, or glass, which is dependent wholly upon the manner and the degree of firing.

The Cumberland and other soft coals, commonly used in this country for burning ordinary building bricks, will not answer for this purpose, as they are too hard to manage, as the successive intermittence in heat is obtained by

very heavy charges of fuel, which are permitted to burn quite low. The quality which our Cumberland, and all soft coals have of swelling, or largely increasing in bulk after being fired heavily, makes this class of fuel still more undesirable for this kind of burning, and besides it is too quick, and has too much flash.

Wood and clean peat are the best agents for meeting the requirements of blue brick and terro-metallic ware burning.

It is impossible to burn this class of pottery in rough open kilns, without excessive cost for fuel, as well as loss in melted and salmon stock.

CHAPTER IV.

THE MANUFACTURE OF BRICKS BY THE HAND PROCESS.

SECTION I. GENERAL REMARKS.

IN describing the processes of brick-making, we shall follow the manner of production by the hand process, as it is in the District of Columbia, for the reasons that the manner of the manufacture of bricks, as it is conducted in the city of Washington and its vicinity, is about the same as that in most portions of this country.

Also, for the additional reason that the common run of building bricks there produced are for strength, uniformity in color, as well as in size, good edges and corners, and for all other reasons that can be named, the best that are made in any part of the world.

The reason for this is that the enormous quantities of bricks consumed by the United States Government and the local government, have, in both cases, to pass the inspection of engineers of the U. S. Army, or of experts employed for the purpose. From this cause the common bricks have reached a high standard, as the annual consumption by both branches of the government have for many years exceeded more than one-half the total production. Pressed or

front bricks have not until lately been extensively used in Washington for facing U. S. Government buildings.

A larger quantity of bricks are made by machinery in the District of Columbia than by hand; but in describing the processes, I shall, for this particular locality, give that employed in producing the hand-made bricks. To do this properly, let us assume that we have passed through one season of manufacture, and have been compelled to stop operations on account of the approach of freezing weather, and from this point I shall start and carry you through the making and burning of one kiln of bricks, which will cover the whole ground in a systematic manner.

The entire process of brick-making by the hand process may be classed under six heads, viz:—

1. Preparation of the clay.
2. Tempering.
3. Moulding.
4. Drying.
5. Setting the bricks in the kiln.
6. Burning.

Generally in all hand-made yards, there are a few men who are more useful to the proprietor of the works than are the usual run of his laborers; they are dependent upon him, and very often they do not know much of any other kind of work outside of the brickyard. The balance of the men generally find employment for the winter as waiters in the city hotels, as oyster shuckers in the restaurants, or as servants in private families, and sometimes as drivers of coal carts and other employments, in which positions they remain

until the work of brick-making is resumed, which is about the middle of April.

The number of men that the proprietor keeps around him during the winter is about four or five for a moderate sized yard; these are usually the burner, and the remainder are from his gang and the best moulding gang. These are the men who do the first stage of the work, or prepare the clay.

Section II. Preparation of the Clay.

This work commences immediately after the other work stops, and the first thing done is to remove the top soil; this vegetable soil is called, in brickyard parlance, "kelly," and the operation of removing it termed "taking off the kelly." In England this soil is called "encallow," and the operation of removing it is termed "encallowing."

The latter term is much more appropriate than any of the others, as it means the act of stripping or laying bare, and as the soil is stripped from the clay and the clay laid bare, it is the term that should be generally used.

The vegetable soil is carried to the level places where the bricks are moulded, called the "floors," and spread over them uniformly to the depth of two inches, and by the return of brick-making season it has become solidly packed. The operation of placing the soil upon the places where the bricks are moulded is termed "kellying the floors."

The clay is now ready to be dug, the soil having been removed from the top, the tools used for digging the clay are the pick, shovel, and crow-bar, the picks are the usual

mining picks, both ends are made flat or chisel-ends, the end of the crow-bar is also flat or chisel-ended instead of pointed.

There is no work done by the day in the hand-made brick-yards, everything is done by the task or contract, just as in the times when the Children of Israel were in bondage to the Egyptians.

All clay is dug by "the thousand," and the price paid is fifteen cents for each thousand of clay dug, "one thousand" meaning clay sufficient to make one thousand bricks, and so on.

The clay is dug in "benches," that is, in sections usually sixteen feet long and running the height of the clay bank. When the laborer wishes to commence work he tells the foreman to measure him off a bench; in counting clay it is estimated that it takes sixty-four cubic feet of clay to make one thousand bricks; all benches of clay are laid off sixteen feet long and four feet wide, every foot in height counts one thousand of clay; if the bank is five feet high the bench will contain five thousand of clay. It does not in fact take even fifty cubic feet of clay to make one thousand bricks; sixty-four feet to the thousand was the quantity when our bricks were the size of the English bricks.

The manner of digging clay is to undermine the face of the bank of clay, leaving small pillars, called "legs," one at each corner and one in the middle; chambers are next cut into the bank at each corner, the "legs" of clay are next picked out, a sharp watch being kept by the laborer to see that the bank does not fall unawares.

If it does not fall while the legs are being picked out, the laborer gets on the top of the bank and driving the crow-bar into the clay, on a line in several places, about four feet back from the face of the bank, "throws" the bench of clay. The material is then picked into lumps and thrown back with the hands, the fine clay is thrown back with the shovel, and the face of the bank is picked regularly, and the bottom levelled, after which the laborer is ready for another "fall." That is, he is ready to repeat what he has just finished.

This manner of digging clay is extremely hazardous; if the common sense of the men who labor at this kind of work does not dictate a discontinuance, then it should be stopped by legislation. A heavy penalty should be imposed upon the proprietor who sanctions this manner of digging clay, and a much more severe one upon the man who is foolish enough to persist in it.

There is not a year in which several cases for the coroner of the District of Columbia do not grow out of this manner of digging clay, besides many injuries that cripple but do not kill.

For many years past this has been the case in all parts of the country; the greatest number of accidents of this character occur towards the end of the winter, when the thaws, which come suddenly, make the clay very treacherous, and often cause it to fall without the least indication or warning.

While the clay is being dug, strips of clay about eight inches wide are left between the ends of the separate benches of clay. They are not dug and are called "combings," and

if the laborers are not very trustworthy there will be more "combings" than dug clay.

The selection of proper clay for the purposes of brick-making, and the advantages of digging the clay early in the winter and of exposing it to the action of frost, have been explained in Chapter II.

The first step in the art of brick-making having been passed by the preparation of the clay, *i. e.*, by digging and exposing it, we are now ready for the second step, that of tempering it.

Section III. Tempering the Clay.

To temper clay means to mix it thoroughly, and prepare it for the use of the moulder, who must have it in a condition not too soft nor yet too hard, but in a suitable state of plasticity to be easily and solidly moulded into bricks.

The ancient way of tempering was by treading the clay by the feet of men or beasts. The clay is now tempered by either of three ways: the first being by hand, the second by the pug-mill, and the third in a ring-pit.

The first method is usually employed for the manufacture of the best pressed bricks, and sometimes in the production of common bricks.

This method is also very often employed in country places.

The man who does this part of the work is called the temperer, and it is his place to throw the clay into a pile the day previous to its being used; while he is spading the

clay into a pile, he at the same time throws water upon it; this pile of clay, when finished for common bricks, contains clay sufficient to make two thousand three hundred and thirty-three bricks, and is called "a soak heap."

The next morning, before the moulder is ready, the temperer commences by pulling part of the "soak heap" down with a hoe; the portion of the clay thrown down is wetted with water, and turned over many times with a spade. Having done this for a while, he next trims the small pile of clay into shape, and commences to cut through it with an instrument called a "slasher," and any stone that he may strike with the "slasher" is picked out of the clay. After cutting the clay for a time in this way, it is again turned over with the spade, after which it is ready for the moulder. This operation is continued until all the clay in the "soak heap" is worked out, after which the temperer throws up another similar pile of clay which is allowed to soak through the night. When hand temperers are employed, in addition to this work, they are required to turn up ten rows of bricks on edge; and, after they are sufficiently hard to wheel, hack them in the drying shed. The tools employed in this kind of tempering are an ordinary Ames' No. 2 spade, one hoe, same as No. 3 English hilling hoe, one wooden box open at one end and top, with a long handle in the solid end, and called a "scoop," used for throwing water over the clay, and one "slasher," which is a piece of wrought iron about three inches wide, three-eighths of an inch thick, and about three feet long from the handle into which it is driven,

the handle being round, and about two and one-half feet long, and two inches in diameter.

The common bricks made from hand-tempered clay are not so good as when made by the other methods of tempering, as the clay is not packed together by any pressure in hand-tempering, and the bricks, after being burned, are very open or porous. When the process is used for making pressed bricks, the result is different, as the bricks after being moulded are pressed very hard in a hand-press.

The next process for tempering is by the pug-mill, or hopper, as it is also called. To explain this process, I shall here have to explain the organization of the "moulding gangs" in the hand-made yards.

When the pug-mill or hopper is used, it is customary for three gangs to make or mould their same day's work from it.

Each gang is composed of one moulder, one wheeler, and one boy called an off-bearer. The moulder shapes the bricks in thin cast-iron moulds from the clay brought to him by the wheeler, who obtains it from the opening in the cylinder as it issues from the pug-mill; the boy off-bears or carries the bricks from the moulding table and lays them in rows on the ground called the "floor," where they are left to dry.

The pug-mill is an iron shaft with knives of the same material about eighteen inches long, two and a half inches wide, and three-eighths of an inch thick, extending from the shaft in four directions, but so placed that one does not follow directly under the other. To trace the knives around the shaft would be like following the thread of a screw. At

the bottom of this shaft, and all on the same level following consecutively are four broad, curved pieces of iron, called sweeps, pressers, or pushers, which terms are synonymous, and their use is to force the tempered clay through an opening near the bottom, in the side of the cylinder or box inclosing the pug-mill.

Sometimes the casing which incloses the pug-mill is made square and of wood, two inches thick usually, leaving the clay to pack into the square corners; at other times the cylinder is formed of iron, cast in sections and bolted together. In the Southern States the entire arrangement of upright shaft, knives and pressers is more often called a "hopper" than a pug-mill.

Mr. Alfred Hall, of Perth Amboy, N. J., has invented a useful improvement in the construction of pug-mills used in the manufacture of brick, terra-cotta, fire-clay wares, pottery, and all work or articles where clay, plaster-of-Paris, or the like have to be brought into a homogeneous and uniform condition to form moulds, or brick, pottery, or other articles of earthenware; and the novelty consists in the construction and arrangement of parts in regard to the vertical revolving shaft and the blades or knives.

In machines of this kind it has been customary to employ knives, pressers, and muddlers of different and various constructions, and they have been secured to a vertical revolving shaft in various ways.

This invention consists in a peculiar blade or arm (shown in perspective in Fig. 4) and a shaft having a special and peculiar mortise, into which the arm or knife is secured.

Fig. 3 is a vertical central section; Fig. 4, a perspective detail of one of the arms or knives; Fig. 5, details of the parts separated, showing their relative formation.

FIG. 3

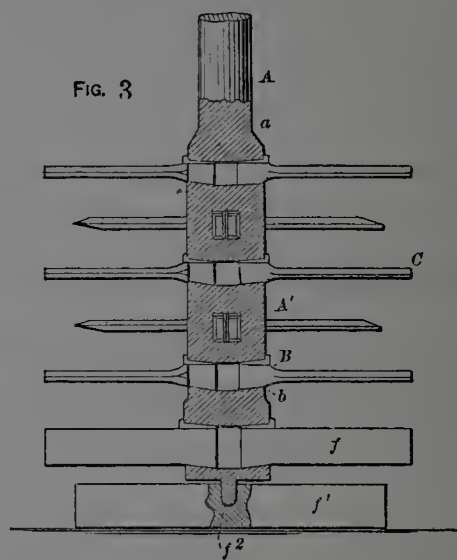


FIG. 4

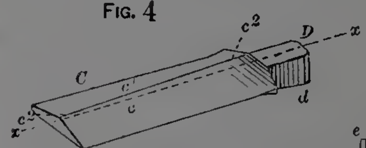
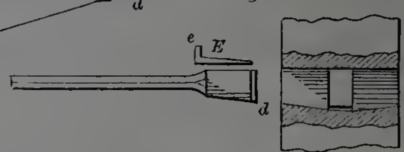


FIG. 5



A is the vertical shaft, to be placed in any suitable cylinder for holding the material to be operated upon. It is supported in position by the framing, so that it can be readily revolved. It has formed in it a series of cross or horizontal mortises, *B*, each adapted to hold the tenon *D* of the blade *C*. Each mortise *B* has its upper side made on a horizontal line, while its lower surface, *b*, is inclined downward from the outer end inward to or nearly to the centre of the shaft, thus giving to the mortise the shape or form in its vertical width of a half-dovetail. The tenon *D* of the blade

C is made in form corresponding to the shape of the mortise *B*—that is, its under face, *d*, is cut away so as to give it an upward incline from the outer end to the inner end of the blade proper, and its outer end is made of such size that it will just fit and enter snugly into the mouth or outer end of the said mortise. As the tenon is pushed farther into the mortise it drops downward on the inclined surface *b* and away from the upper side of said mortise, and leaves a space above it, into which the key *E* is driven. When the tenon and key are both inserted the blade will not work loose, because the inclined surface *b* and the increasing thickness of the tenon operate to give increasing force to hold the blade against any movements tending to draw the blade outward. The material which is being acted upon will exert a pressure on the ends of the keys *E* and prevent them from working loose. The blade *C* has its under face flat or made to a horizontal plane. Its upper side is gradually thickened from the edges to a line drawn diagonally from the middle of the outer end to a point on the inner end next the tenon, midway between the middle of said blade and the rear edge.

In Fig. 4 the dotted line x x represents the middle line of the blade. The diagonal line c^2 c^2 is the line of greatest thickness of the blade. The blade thus formed provides an upwardly-inclined front face, *c*, which is wider at its inner end next the shaft and narrower at its outer end. The rear face, c^1, is wider at its outer end than at its inner end. The peculiar construction of the blade gives much better results in mixing the material in the cylinder or pits. The mate-

rial is sooner brought into a homogeneous mass and into the required condition for the moulds.

The key *E* is preferably wedge shape, as shown.

f are the lower scrapers, which are provided with tenons of half-dovetailed form, and are secured in the shaft in the same manner as the blades *C*.

In case of accidental breaking of one of the blades the broken blade can easily be removed and another one substituted.

The pug-mill and cylinder inclosing are so placed that the pivot or spindle at the bottom of the mill will be in the centre of the diameter of a semicircular pit which, to contain clay for three gangs, measures eight feet from the centre of the pug-mill shaft to the edge or brick face of the pit, which is four feet deep.

This semicircular pit is usually walled around with bricks, which should be hard burned, and the bottom formed of two inch oak planks, cut wedge shape.

Directly in front of the pug-mill there is a fan-shaped hole or pit, which allows the wheeler to cut the clay away with a spade as it issues from the hole in the side of the cylinder at the bottom, inclosing the mill. If the pug-mill is turned by a horse, it is usual, if the clay bank is too far away to be conveniently filled with wheelbarrows, to harness the animal to a cart, and haul the clay to fill the pit, after the work of grinding has been completed, which usually requires about six hours. A long pole fixed in a yoke in the top of the shaft is the leverage by which the pug-mill is turned.

The pit around the pug-mill, when the clay is ground by horse power, holds usually material sufficient to make seven thousand bricks; after the pit has been filled it is the duty of the temperer to see that sufficient water is let to the clay to soak it.

The clay in the pit is left to soak over night, and in the morning the temperer gets into the pit of mud, and first digs a hole in the clay, next to the pug-mill, throwing the material into the mill.

It is necessary to grind the same clay through the pug-mill several times, the first thing in the morning, before it comes to the proper degree of plasticity for moulding; this operation is called "sizing the clay."

The temperer having secured the proper plasticity, or "size" for the clay, he continues to shovel the mud into the pug-mill, each wheeler of a gang, in turn, spading it away from the bottom of the pug-mill, as it is forced through the orifice at the base of the cylinder.

During this process of tempering, a small stream of water is continually running into a barrel sunk into the ground, near the box of the pug-mill; if some of the clay is very hard, there is used a large quantity of the water from the barrel; but if it is soft, only a small quantity of water is used.

Sometimes mud, seemingly almost slush, will be thrown into the pug-mill; but when it issues at the bottom, it is stiff and firm; when this is done, the men call it "grinding the water out of the clay;" but it is really grinding the water into the clay, and thoroughly mixing it.

The work of the temperer for the pug-mill is confined

entirely to the clay in the pit, and he has nothing to do with handling any bricks, as is the case with the hand-temperer before mentioned.

The pug-mills are sometimes driven by steam-power, instead of being turned by a horse; in case they are driven by steam, there is a large bevel-wheel placed on the top of the pug-mill shaft, which bevel-wheel gears into a smaller pinion on a shaft keyed to a large pulley.

The pulley on the pug-mill of this character is generally about five feet in diameter, and eight inches face; if the pulley is too small in diameter, the mill is liable at times to clog and stop, leaving the belt either to slip or break.

When a machine of this kind is used for tempering clay, the pit which surrounds it can be enlarged to any reasonable extent, to meet the requirements of almost any sized yard.

The power of the small pinion into the large bevel-gear wheel is usually about one into six; *i. e.*, the pinion makes six revolutions while the wheel into which it meshes makes but one revolution.

The amount of thoroughly tempered clay which a mill of this kind will turn out is surprising; four men constantly throwing clay into it cannot overstock it, if it is going at any kind of quick speed.

The speed can be regulated so as to travel at any required gait; but when it is intended for fast work, the pushers at the bottom of the pug-mill shaft must be very strong, and braced together with one-half inch iron rods.

The temperers who work at the pug-mills must be very able men, and thoroughly understand their business, and the nature of the clay in which they are working.

The tools used are for each temperer one Ames shovel, No. 2, one hilling hoe, same as that used by the hand-temperer, and one bucket.

The pug-mill which has been described is the best thing that can be used for tempering brick or terra-cotta clays; it packs the clay very closely, and the ware made from material tempered in this manner is very homogeneous.

The cost, excluding engine, complete, and in running order, ought not to exceed three hundred and fifty dollars, which includes timber, framing work, tie rods, etc.

The next manner of tempering is by the ring-pits, which furnish clay for six gangs, and are run either by horse or steam power.

These pits are about twenty feet in diameter, two feet in depth, and hold clay sufficient to make fourteen thousand bricks; they are cased around with hard-burned bricks, and the bottom is usually covered with oak planks, cut wedge shape. Hard pine is cheaper than oak, and is also used.

There is a pedestal firmly set in the centre of the pit, upon which the machinery that works the tempering wheel is placed.

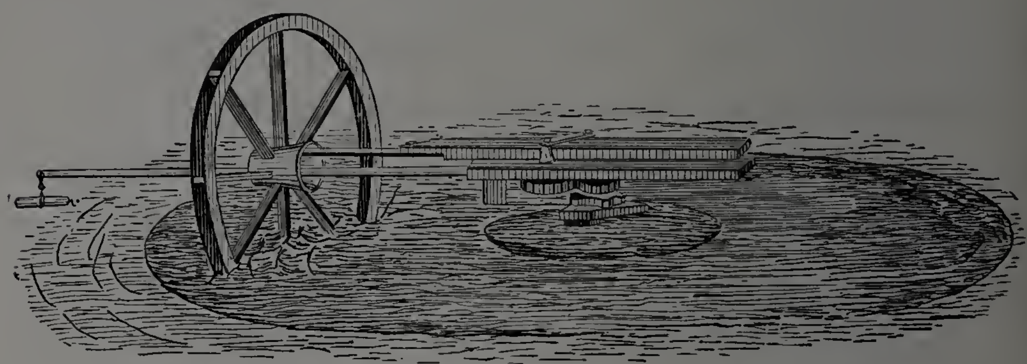
For a ring-pit worked by horses, shown in Fig. 6, there is a long shaft of iron passing through the centre of a wheel, about six feet in diameter, called the tempering wheel, and terminating beyond the ring far enough for two horses to be hooked to it, and have room sufficient to travel around the ring with it.

There is a gearing of wheels so arranged as gradually to push the tempering wheel from the centre to the outer edge

of the pit, while the wheel is revolving around the circle, and when it reaches the outer edge to again gradually draw it towards the centre.

In the pits, using horses to work them, there is sometimes a small wheel, about one foot and six inches in diameter, and which travels in a level track around the edge of the ring, supporting the long iron shaft which passes through it.

Fig. 6.



Recent changes have been made in the wheel by placing the spokes at an angle, producing a dish in the wheel, so as to suit the circle of the pit, saving the labor of the horses; it also grinds and leaves the surface of the clay level in the pit during and after grinding. The open-tooth, and the box racks, are now in use; the latter have the cogs placed on the inside around the rack, a rib on the top side placed lengthwise, and when coming in contact with a pin placed in the bottom side of the cross-bar on the saddle, causes the rack to shift. The racks can be made of different lengths, to suit smaller sized pits, when necessary. Directions can be furnished for setting the wheels on application to the manufacturers.

When steam is the motive power, the principle of construction is about the same; but the shaft which passes through the tempering wheel does not extend much beyond the edge of the ring, and the whole machinery is attached to a vertical shaft, and on the top is a heavy bevelled gearing.

Serious difficulties have been encountered in constructing and operating machines of this class, from the fact that the power which has propelled them has been communicated through some horizontal shaft above the receptacle for the material to be tempered, which arrangement has necessitated the use of a long vertical shaft to communicate the motion of such horizontal shaft to the shaft and gear-wheels which propel the tempering wheel. This arrangement of the parts has rendered necessary expensive, and in many cases inconvenient, frame-work to support the shafting, which often interferes with the efficient working of the machine, and is always a large addition to its cost. Another, and a very serious objection, has arisen from the fact that the pinion which meshes into the circular rack upon the upper surface of the clay receptacle has been constructed in accordance with well-known rules as to its diameter and the pitch-line of its teeth, which form of construction, it is claimed, is found defective in this particular case.

When steam power is employed for driving these machines, two of the pits are placed on the same line, the distance between the nearest points of the circles being about six feet.

There are no separate temperers for the ring-pits of either class; the driver of the horses in one case, and the engineer

in the other, let the water into the clay, and see that it is properly tempered. It requires two of these pits, of either class, to temper clay for six gangs, as it is worked out of one pit, while the other pit of clay is being tempered. The sheds, which must be maintained over the ring-pits of both classes, is much more expensive for the ones that are run by steam-power than for the other class, as the timbers have to be very heavy, and well framed and braced. Sometimes twenty-eight thousand of clay, which is sufficient for twelve gangs, is worked out of two ring-pits daily; when this is so, the pits are filled after the gangs stop work, and the clay tempered during the night time.

After the clay is tempered in ring-pits, it is covered with large battened panels, made of light pine wood nailed together, the object being to keep the clay moist, and prevent it from drying on the top before it is used. The laborers in the brick-yards like the clay tempered in ring-pits, as they can go in separate gangs at any time and commence work without waiting for a complement of gangs, which has to be done when pug-mills are used for tempering.

It is no unusual thing for brick-yard gangs, in the hot season of the year, to commence their task at about twelve o'clock at night, when the moon gives sufficient light, and have their work of moulding done before seven o'clock in the morning; the ring-pits facilitate this more than do any other mode of tempering the clay.

The invention of Mr. Henry Aiken, of Philadelphia, Pa., is shown in Figs. 7, 8, 9, and 10, and it relates to improvements in that class of clay-pits in which the tempering-wheel

is caused to traverse round the pit by power derived from a stationary engine or other motor; and the main object of his invention is to dispense with complex driving-gearing, and to apply the power more advantageously than usual, a further object being to simplify the devices by which the radial movement of the tempering-wheel on its shaft is effected, and to so construct the same that a vertical movement of the wheel is allowed without danger of throwing the operating mechanism out of gear. These objects he attains in the manner which I will now proceed to describe, reference being had to the drawings, in which—

Fig. 7 is a plan view of a clay-pit with his improvements;

FIG. 7

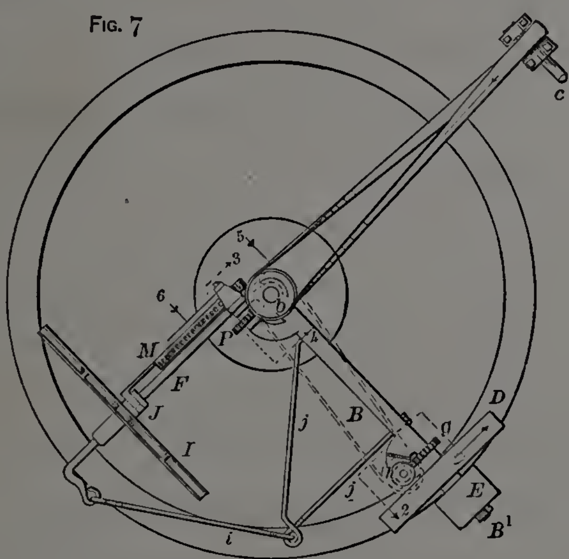


FIG. 9

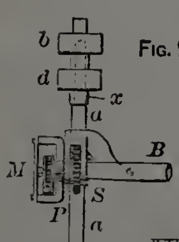


FIG. 8

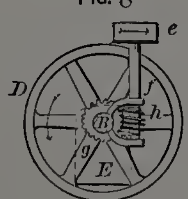
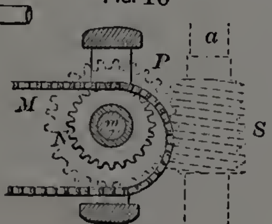


FIG. 10



and Figs. 8, 9, and 10, sections on the lines 1 2, 3 4, and 5 6, Fig. 7, respectively.

A is the pit, in the centre of which is a vertical standard, *a*, and to the top of the latter is adapted a loose sleeve, *x*, carrying two pulleys, *b* and *d*, the former of which receives power from any adjacent shaft—for instance, that shown at *c*—while the pulley *d* transmits this power, by means of a suitable belt, to a pulley, *e*, carried by a vertical shaft, *f*, adapted to bearings at the outer end of a radial arm, *B*, the inner end of which turns on the central post *a*. From the outer end of the arm *B* projects a short shaft, B^1, carrying a loose traction-wheel, *D*, the periphery of which is adapted to the rim of the pit, and a worm-wheel, *g*, on the hub of the traction-wheel gears into a worm, *h*, on the shaft *f*. (See Fig. 8.) For the sake of economy, it is preferable to make the wheel *D* comparatively light, and to increase its traction power by hanging upon the outer end of its shaft a box of clay or other cheap weight, *E*. The arm *B* is connected to the outer end of the shaft *F*, which carries the tempering-wheel *I*, by means of the link *i* and rods *j j*, and the tempering-wheel is hung to, or forms part of, a sleeve, *J*, so adapted to the shaft *F* that it can be moved from or toward the centre of the pit, this movement being effected, as usual, by means of the double rack *M* and pinion *N*, Fig. 10, the direction of the movement depending upon whether the upper or lower rack is in gear with the pinion. Instead of rotating the pinion *N* from a central shaft by means of spur-gearing, as usual, however, it is secured to one end of a spindle, *m*, adapted to bearings at the inner end of the arm

B, and carrying, near its opposite end, a worm-wheel, *P*, the teeth of which engage with a worm, *S*, secured to the stem *a*. (See Fig. 9, and dotted lines, Fig. 10.)

When power is applied to the shaft *f* at the outer end of the arm *B*, the traction-wheel *D* is caused to revolve, and travels round the rim of the pit, carrying with it the arm *B*, and consequently the shaft *F* and tempering-wheel *I*, while at the same time the movement of the worm-wheel *P* around the worm *S* on the central stem *a* causes the rotation of said worm-wheel and the operation of the mechanism which effects the radial movement of the tempering-wheel.

It will be evident that by the above-described arrangement the power required to effect the movement of the tempering-wheel is applied more directly, and with less loss by friction, than when this power is applied to the inner end of the tempering-wheel arm by means of gearing from a central rotating shaft, while the use of the simple traction-wheel *D* at the edge of the pit obviates the necessity of locating costly and inconvenient mechanism at this point.

By the use of the fixed worm *S* on the stem *a*, and the worm-wheel *P* carried by the arm *B*, the said wheel *P* can be caused to revolve at the required speed without the intervention of the usual system of gearing, which is complicated and expensive, and causes loss of power by friction.

It will be observed in Figs. 7, 9, and 10 that the inner end of the shaft *F* is pivoted to the shaft *m*, which carries the pinion *N* for operating the rack *M*, so that when the tempering-wheel rises or falls, owing to inequalities in the

bottom of the pit, the centre of movement will be at the shaft *m*, thus preventing the risk of throwing the rack out of gear with the pinion, which this movement causes in machines of this class as usually constructed.

It is not absolutely necessary in carrying out this invention that both the arm *B* and shaft *F* should be used. For instance, the traction-wheel and its operating devices might be carried by the end of said shaft *F*, the belt which transmits power from the pulley *d* to the pulley *e* in such case being arranged at such a height that it will not interfere with the tempering-wheel *I*.

Section IV. Moulding.

The next step in the process of producing hand-made bricks is that of moulding the clay after it has been tempered, and this is performed in light cast-iron boxes, having both the top and bottom open and unobstructed, and which are twice as long as they are wide, and are called moulds. The wheeler brings the tempered clay to the moulder, and piles it upon a wooden stand in front of him. The stand, which is called a "table," is about four feet square, and made in height to suit the moulder.

On the left-hand corner of the table there is screwed securely a piece of cast-iron, one-half inch thick, nine inches wide, twelve inches long, and turned up at one end, and down at the other; this iron is called the "moulding cleat," and is shown in Fig. 11.

The moulder, with both hands, pulls down a lump of

the tempered clay, takes a handful of moulding sand in his right hand, from a tub close by, throws the sand over the lump of clay, works clay and sand into a peculiar shape, called "the warp," and dashes it down with great force into the mould which rests upon the moulding cleat, using

Fig. 11.

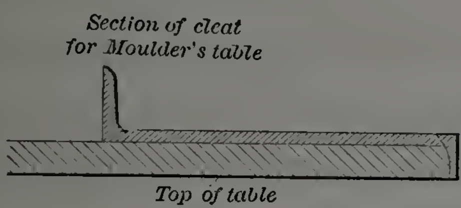
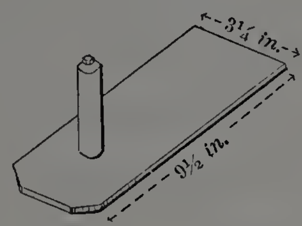


Fig. 12.



both hands. Having done this, he takes an instrument, somewhat resembling a plasterer's trowel, called a "plane," shown in Fig. 12, with which he strikes off the clay piled above the top of the mould.

The off-bearer now takes the mould and the inclosed brick, lays the brick on the "floor," scrapes the inside, and particularly the corners of the mould, with a knife suspended by a string from his side. The off-bearer places the cleaned brick mould in a sand tub convenient to the moulder, and by the time another brick is made, he is ready to place it alongside of the other on the floor. This is continued until there are fifty-eight bricks in the row, and the rows are continued until they number forty; then part of a row containing thirteen bricks is made, which completes the "task" of moulding.

Each gang, for a day's work, produces two thousand three hundred and thirty-three bricks, three gangs seven thousand, six gangs fourteen thousand bricks, and so on.

The hand-made yards in the District of Columbia vary in their capacity from three gangs to twenty-four gangs. The material used for sanding the moulds is very highly impregnated with oxide of iron and mica; the iron gives a beautiful red color to the hard-burned bricks, and the mica allows the brick to slip easily from the mould.

The art of perfect moulding by hand consists in filling, uniformly, every portion of the brick mould, and in so manipulating the clay and moulding sand thrown into it, that the brick shall contain no cracks or "sand flaws," and in so "planing" off the clay from the top of the mould that neither hollow nor swelling, called a "belly," is made on the flat part of the brick.

The usual time for a good gang to do a day's work of moulding is from five to five and one-half hours.

The moulder is the head of each gang; all complaints against him, his wheeler, or his off-bearer are made to him, and he sees that any imperfections are remedied.

It is the duty of each moulder to get the moulding sand from the sand-pile and spread it out in the sun to dry; the off-bearer rakes the dried sand in a pile, and sieves it into a half barrel, called "the tub;" after it is sieved, he wheels it into the brick-shed and covers it, so that no water can get into it.

The wheeler gathers the stones and hard lumps of clay that have been thrown out by the moulder, and wheels them to some out of the way place.

The tools and appliances used by a hand-made brick-gang, in addition to those which have been mentioned, are as follows, viz:—

One Ames' spade No. 2, for wheeler.

One clay barrow for wheeler.

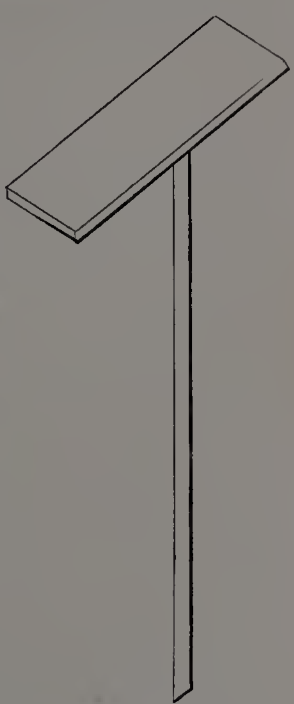
One sieve, No. 42, for off-bearer.

One brick barrow for off-bearer.

One brick barrow for moulder.

There is a tool used for scraping off and levelling the moulding floor, and levelling the bottom of the drying-shed preparatory to hacking the bricks. It consists of a piece of light pine board, one inch thick, twenty inches long, by six inches wide, set upright, with a long light handle in the centre. At the bottom is tacked a thin piece of steel, generally an old wood-saw blade, with the teeth turned upward, and the smooth edge forming the bottom.

Fig. 13.



Moulder's Lute

This tool is never furnished by the proprietor of the yard, it is always the private property of the moulder. The tool is called a "lute" (Fig. 13), and the owner of it generally seems to think as much of it as he does of his wife, and makes as much disturbance about it, if it happens to become mislaid or stolen, as if he had lost his whole family.

It is always the custom for the moulder to get the "table, stool, and water bowl" in readiness before the first day's make of bricks is produced, in the commencement of the season, on which day none of the hands in the yard do more than one-half the usual task; twenty rows of brick are made, instead of forty; but all hands are allowed and paid for a full day's work.

The next step in the process of manufacture is the drying of the bricks.

It is the duty of the moulder to take entire care of fifteen rows of the bricks made by him, and laid out on the floor by the off-bearer; the wheeler is also charged with the care of fifteen rows, and the off-bearer with the remaining ten rows, and the fraction of a row, and the task of no member of the moulding gang is completed until the day's make of brick are safely placed in the drying-shed; and if portions are lost through exposure, from the negligence of any member of the gang, the value of such loss is charged to him, and deducted from his pay.

Section V. Drying the Bricks.

The first step in the drying of hand-made bricks is to turn those upon edge that were made the day previous; if there are no indications of rain, the bricks are "turned up" early in the morning, and allowed to stand upon edge, exposed to the sun until about four o'clock in the afternoon, when each man "takes in his share," and carefully hacks them in the drying-shed; usually they are hacked about eight courses high on the edge, and the hacks kept separate, to allow circulation of air. There is a space left between the bricks of one-half inch, and a "head" or pier is built at each corner of the "rows."

If there should be indication of rain before the usual time for "taking in of the bricks," and any of the bricks are hard enough to handle, they are wheeled into the shed; if not firm enough, they are left to be "washed," that is, the

bricks on edge are again laid flat, and the rain falls upon them.

Some clays will stand this, but bricks made of other clays are entirely destroyed, if not by the rain, then by the sun, as they break in half as soon as the heat again strikes them.

Bricks that will stand "washing" are wheeled into the shed and set for salmon or arch bricks, when they go into the kiln.

The bricks having been exposed to the rain are called "washed bricks"; they have a rough appearance, and are generally not much esteemed, but they make the strongest bricks that come out of a kiln; and when hard-burned, they have no equal for foundation or sewer work.

The drying-sheds usually run the length of the brick floors, and immediately adjoin them, there being one shed on each side of a floor. The sheds are usually cheaply built, entirely of boards. They are about twenty-eight feet wide between the outside posts, four feet and six inches high at the sides next to the floors, and run to an incline of about thirty-five degrees on each side to the ridge pole, which is supported by chestnut posts in the centre of the shed.

The roof is made by allowing the boards to extend from the ridge pole to the stringer at the low part of the shed, separating the bottom boards far enough and covering this opening with a lap-board.

No support of any kind is given to the boards between the centre of the shed and the stringer or low portion, as the water not only runs down the top of the boards, but

follows the underside also, and should this water meet any obstruction, like a stringer or support of any kind, before it reached the end of the board, it would drip into the shed and ruin the bottom of the shed as well as the bricks.

The ends of the brick sheds are closed; but the sides are usually left open. The boards forming the roof often sag in the centre; but it is seldom that water gets into the shed from this cause.

After remaining in these sheds for about two or three weeks the bricks are generally in condition for setting; but during rainy periods it often requires a longer time to thus naturally dry the bricks.

An Improved Brick-drying Shed.

Heretofore, as we have explained, the process of drying bricks has been to spread them upon the ground, one separated from the other, to allow the sun and air full access, and when they were partially dry they were piled in a stack, where the process of drying was continued until the bricks were in a fit condition to be burned. By this method of drying, which in itself was a slow process, the bricks were liable to be damaged when on the ground by sudden storms of rain washing the corners off and roughening the surface thereof, producing an undesirable grade known in the market as "washed bricks." The necessary handlings required in stacking, or, as it is technically called, "hacking," damage the bricks by chipping off the corners and bending the same, as well as requiring a large expenditure of labor, whereby

the cost of the bricks is materially increased; but by this improved shed, which can be used for drying either hand-made or wet, machine-made bricks; these defects have been greatly obviated, and the bricks are dried with greater facility.

Fig. 14 is an end elevation of a brick-drying structure embodying a portion of the invention, partly in section.

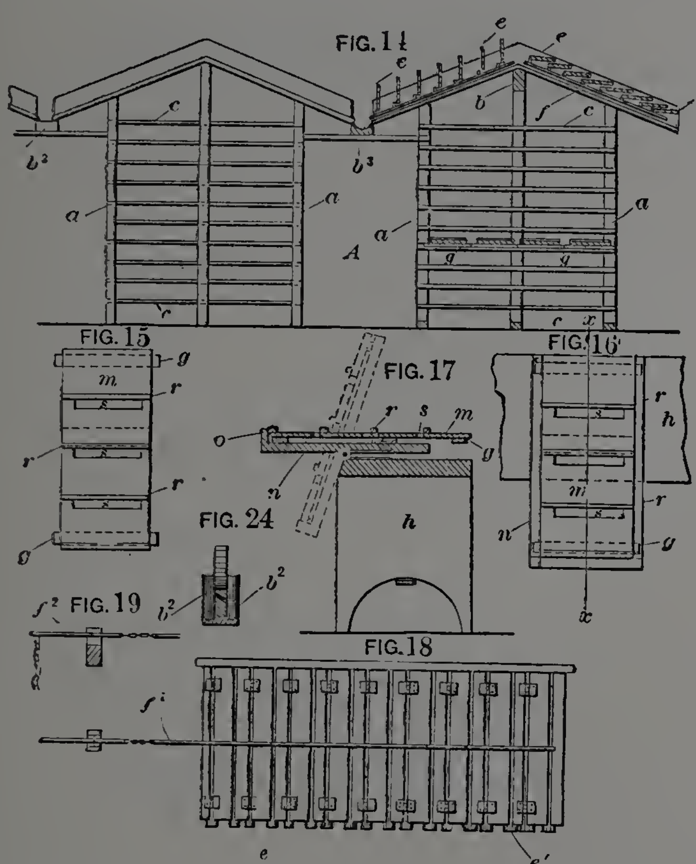


Fig. 15 is a plan of a brick-board. Fig. 16 is a plan view of a part of a bench having attached thereto a mould-lander or tilting-board, upon which is a brick-board. Fig. 17 is a vertical section taken through line x of Fig. 16. Fig. 18 is a plan view of the hinged boards. Fig. 19 is a vertical section of the lifting mechanism attached to the lever of Fig.

18. Fig. 20 is a side elevation of a part of the brick-drying structure, partly in section. Fig. 21 is a plan of a brick-board mounted on wheels. Fig. 22 is a side elevation of Fig. 21. Fig. 23 is a cross-section of the ways on which the brick-board car moves, and Fig. 24 is a cross-section of the rafter or beam b^2 in Fig. 20. Fig. 25 is a plan of a modi-

FIG. 20

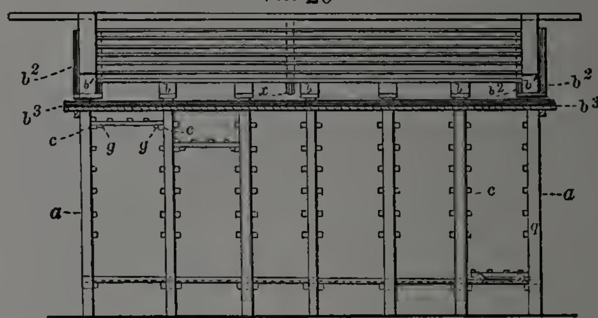


FIG. 21

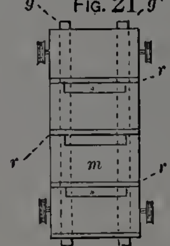


FIG. 22

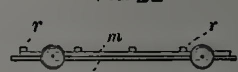


FIG. 23

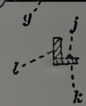
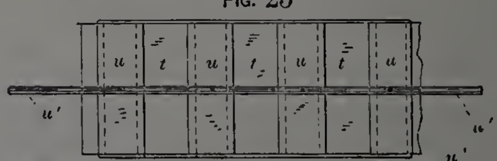


FIG. 25



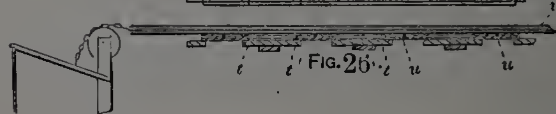


FIG. 26

fication of the movable roof. Fig. 26 is a vertical longitudinal section taken through a line directly under the rod u' in Fig. 25.

In the Figs. 14 and 20, a a are uprights, which stand preferably apart at the same distance from one another, being about equal to the length of the brick-boards, as

shown in Fig. 20. The uprights support the rafters *b* and receive the cleats *c*, arranged one over the other, and in such a position as that when the brick-boards are laid from one series of cleats to the opposite one the brick-boards will lie approximately level.

The roof may be formed so that it may be opened to allow the sun and air to enter, or be closed to exclude the rain or dew. This may be accomplished by pivoting the roof-boards *e*, Figs. 14 and 20, and connecting them by a strip, *f*, of wood or iron, whereby all the pivoted boards may be opened or closed at once, as shown in Fig. 14. The strip *f* may be operated directly by the hand, by a lever, or by any suitable means.

Three ways of arranging the roof-boards so that the air may be admitted or excluded are shown in the drawings, Fig. 14 showing the pivot in the centre and the boards when closed, overlapping in a manner common to window-shutters, Fig. 18 showing the roof-boards hinged to stationary strips laid on the rafters, gutters e^1 being provided beneath the joints. The hinged boards shown in Fig. 18 are lifted by a rod or strip f^1, which may be operated either by hand directly, or by a lever f^2, pivoted or fulcrumed as shown in Fig. 19, and connected to the rod f^1 by chains or other suitable means, whereby all of the hinged boards can be lifted or lowered simultaneously. The weight of the rod f^1 upon the boards keeps them down tightly when closed. The hinged boards are arranged at right angles to the ridge-pole, and may extend from one end of the drying-racks to the other. The lever f^2, Fig. 19, may be operated by a

rope of convenient length attached to one end of the lever, as shown. The third way in which the roof-boards may be arranged is shown in Figs. 25 and 26, in which *t* are stationary boards secured to the rafters, and which are overlapped by the sliding boards *u*. The fixed boards may have gutters on their upper side near the joints, as at t^1, Fig. 26, and if necessary gutters may also be made on the top of the boards *u*, in the same figure. Small wheels may be let into the under side of the sliding boards, moving on the under boards or on tracks, in order to facilitate the movement of the sliding boards. The sliding boards *u* are moved by the rod u^1, Figs. 25 and 26, which in turn is operated by the mechanism shown in Fig. 26, suitably connected thereto, which mechanism is attached to both ends of the rod, in order to open and close the sliding boards, and a hood may be used to cover the ridge-piece and the joints at that place.

The brick-boards *m* are formed with projecting cleats *g*, Fig. 15, on the under side, so that when the boards are placed side by side on the cleats in the brick-drying structure the extremities of the brick-board cleats *g* will abut, and thus form an opening between the boards, through which the air may freely pass. The cleats *g* on the brick-boards are arranged to engage with the cleats *c* in the brick-drying structure, so that the boards may be readily and securely held in position without any danger of sliding off. The boards *m* are further provided with strips *r* upon the upper side, as shown in Fig. 15, against which the brick-mould rests when the brick-board is being loaded. Openings, as *s*, Fig. 15, may be made through the brick-board *m*,

to permit the passage of air. The boards may be further strengthened by a cleat on the under side, at the middle.

Adjacent to the brick-drying structure the inventor constructs a bench *h*, Figs. 16 and 17, to one edge of which is pivoted a tablet or tilting-board *n*, Fig. 17, of a sufficient size to hold the brick-board *m*, which bench may be placed in close proximity to the brick-machine, when the bricks to be dried are so made.

The manner of placing the green brick upon the brick-board is as follows: The tilting-board *n* being in its loading position, as indicated by the dotted lines on Fig. 17, the brick-board is placed thereon, and is held in place by a stop-piece *o*, and the workman takes the mould from the machine, and, resting it upon the strip *r* upon the brick-board, turns it and deposits the mould, with its contents of green brick, upon the brick-board without injury. This is repeated until the brick-board is full, and when the last mould of brick is laid on, the weight of the brick causes the tilting-board to revolve, which then comes to a horizontal position, as in Fig. 17. The moulds being taken off of the bricks, the brick-board, with its load of brick, is then removed to the drying structure, which is near at hand, where they remain without further handling until dry and ready for burning.

The tilting-board *n* is so constructed or pivoted that when the brick-board is removed it returns to its loading position. Several of these tilting-boards may be placed between the brick-machine and drying-racks—as many as may be necessary.

If desirable, the brick-boards may be mounted upon wheels, as shown in Figs. 21 and 22, either grooved or flat, and move on tracks laid upon the cleats, as in Fig. 20, in the drying structure, or secured in some other suitable manner to the uprights *a*, and having a slight pitch or descent from one end of the drying apparatus to the other, in order to facilitate the movement of the loaded cars on the tracks. The cars, after being loaded with the green brick, are placed upon the tracks and moved to the other end, one after the other, until each track is full, and in order to prevent the cars from striking each other too heavily, and thus displace the brick, their descent may be checked, either by a workman or by other suitable means. When the brick-boards are mounted upon wheels, the cleats g^1 on the under side of the brick-boards are placed so that they extend beyond the ends of the cars, as shown in Fig. 21, and thus admit the circulation of air.

The rails may be constructed as shown in Fig. 23. The rail *j* is secured to a strip *k*, and has a side-piece *l*, as a further prevention against the cars slipping off the track.

In order that no moisture can possibly leak through upon the brick, the inventor provides, in addition to the other means, gutters, as b^2, Fig. 20, extending from the ridge-piece to the eaves, under the joints where the shutters meet the rafters b^1, to carry off the water.

The brick-drying structures may be one hundred feet long, more or less, and in building them the inventor prefers to place them so that the eaves of one may touch, or nearly so, those of the other, as shown in Fig. 14, and at or under the

point of meeting to provide a gutter b^3, Figs. 14 and 20, suitably pitched and supported, into which the gutters b^2, Fig. 20, and e^1, Fig. 18, may lead. By this construction a covered way a, Fig. 14, is made for the passage of the workman, and all the operations can be carried on without regard to the weather, and complete protection is assured.

If deemed expedient, the sides and ends of the drying structure may be protected by movable parts similar to those in the roof; or protectors made of several boards nailed together, of sufficient height, may be used.

The roof may be extended, if desirable, so as to cover other operations in the process of brick-making, so that the brick-yard may be completely covered, and it can be adapted to works producing bricks either by hand or machinery, and it is especially valuable wherever fine front or ornamental bricks are manufactured.

Section VI. Description of Wheelbarrows; Setting and Burning the Bricks; Improvements in constructing Permanent and Temporary Kilns.

a. Description of Wheelbarrows.

Wheelbarrows, which are important appliances of a brick-yard, are usually of one of three different styles of construction; one kind being for the purpose of carrying the clay from the pug-mill or ring-pit to the moulding-table, which variety is called a "clay-barrow;" another is for wheeling the green bricks from the drying-sheds to the kiln, and this

kind is termed a "brick-barrow;" and the third is used for wheeling moulding sand to and from the drying-floors; this is called a "hopper" or "box-barrow."

In the clay barrows the back is made slanting, so as to throw the weight of the clay well over the centre of the wheel; but in the brick barrows the back is made so as to form right angles with the side bars, and the wheel protrudes through the back of the wheelbarrow about one-quarter its diameter, as shown in Fig. 31.

The hopper or box-barrow has all its sides made on a slant of about 30°, being, of course, larger at the top of the hopper or box than at the bottom. A great many of these barrows were formerly made with wooden wheels, and had iron gudgeons, which worked in wooden boxes on the under side of the handles; but the majority of brick-yard barrows are now made with iron wheels, spindles, and boxes.

Sometimes brick-yard barrows are so constructed as to be easily folded up for transportation, or when not in use, and are employed and found useful for brick-yard plants which require frequent changes, as for the construction of tunnels, culverts, etc., on the lines of railways, and for other purposes. Such a barrow is shown in Figs. 27, 28, 29, and 30; and it consists in certain constructions, combinations, and arrangements of parts, whereby a very strong and cheap wheelbarrow is produced, which can easily be folded for economizing room in transportation, and thereafter put into working order in very little time.

When it is desired to employ this form of wheelbarrow for handling bricks, the back bars *F* should form a right

angle with the side bars *A*, and the wheel *D* should be moved forward and cleave the back and bottom about one-fourth of the diameter of the wheel, in order to relieve the weight upon the handles, as in Fig. 31.

FIG. 27

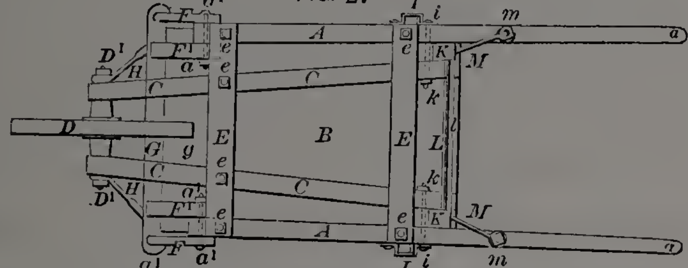


FIG. 28

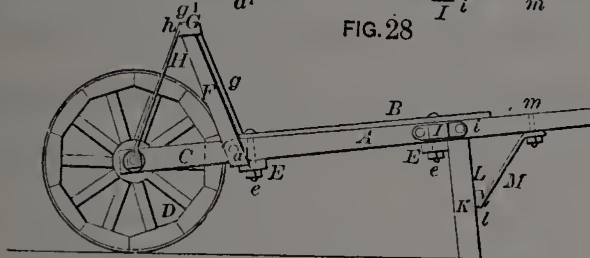


FIG. 29

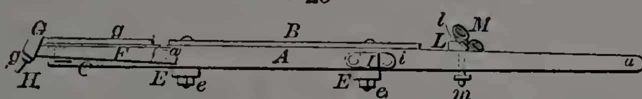


FIG. 30

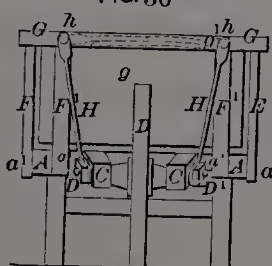


Figure 27 is a bottom view of a folding wheelbarrow. Fig. 28 is a side elevation of the same. Fig. 29 is a side view of the same when folded up, and Fig. 30 is a back view of the barrow.

When the wheelbarrow is not in use, and is either to be

stowed away or packed for transportation, the nuts are removed from the wheel-bolt D^1, the bolt removed, and the wheel D taken off. The braces H are swung up until they meet on the inclined edge g^1, where they remain by means of friction. The back-board frame, with the back-board g is now turned down upon the wheel-bars C, forming thereby an extension of the bottom B. The braces M are now disengaged from the bolts m, and folded together on the inclined edge l of the cross-bar L. Finally, the legs K are swung up between the side bars A, and the folding up of the wheelbarrow is completed, as represented in Fig. 29.

To get the wheelbarrow in working condition again, the described operation is reversed. The folded wheelbarrow requires very little room for stowing away, and may be utilized for many purposes for which it is particularly adapted on account of its large platform.

The side bars, wheel-bars, and their respective cross-bars, by their peculiar construction, constitute a frame of great strength, and of easy access to its component parts in case of accidental breakage or disarrangement, and, as a whole, it is an article of small expense and great simplicity.

A represents the side bars terminating in handles a in front, and extending to the back end of the bottom B. C represents the wheel-bars, which are fastened to the bottom B between the side bars, and extend back to the wheel D. The side and wheel-bars are fastened together and to the bottom B by means of cross-bars E and bolts e. Near the back ends of the side bars A the frame of the backboard is fastened. The frame consists of two outside bars F, and

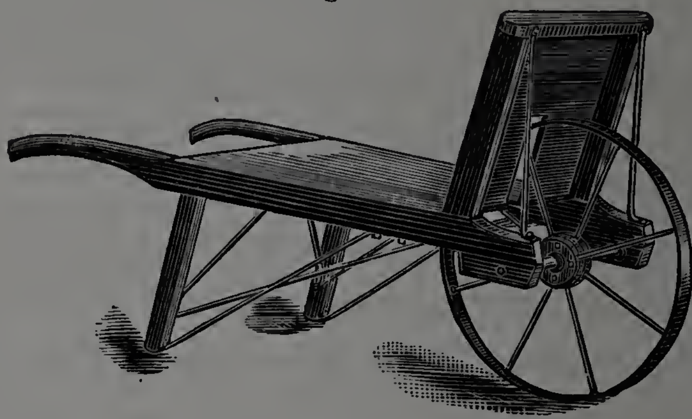
two inside bars F^1, hinged in pairs to the side bars A by means of bolts a^1, and united on top by a cross-bar G. The backboard g proper is fastened to the inside bars F^1, and the backboard frame is kept in proper position by braces H fastened outside of the wheel-bars C by means of the wheel-bolt D^1, the wheel used having, by preference, a hollow hub, which revolves on the bolt.

The upper ends of the braces H are pivoted at h to the cross-bar G, the edge g^1 of which is inclined in the direction of the braces H, when fastened, so that they may be with ease swung around and folded together on the edge, when they are unfastened from the wheel-bolt D^1. The side bars A are provided with sockets I, which are of the usual construction, and applied in the usual manner. Two of the bolts i, by which the sockets I are fastened to the side bars, serve as pivots for the swinging legs K, and for that purpose pass through the side bars, the legs, and the wheel-bars C, thus keeping the latter, by aid of the nuts k, from lateral movement. The legs K are connected by a cross-bar L, with an inclined edge l, to permit the easy swinging of the braces M, which are pivoted thereto, and secured by their upper ends to the under sides of the side bars A by the bolts m.

The barrow shown in Fig. 31 is for wheeling bricks, and it has a large malleable iron wheel, which is an aid to the laborer. The barrow is thoroughly braced, and is built so as to combine great strength with lightness of construction, and with ordinary care such a barrow should run and do good

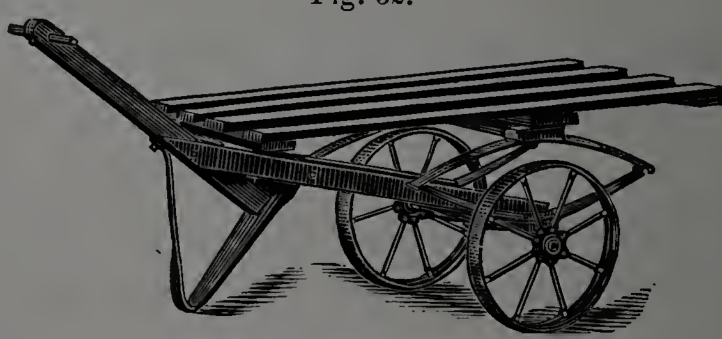
service for ten or twelve seasons, and the usual price of such a wheelbarrow is $6.50.

Fig. 31.



The brick truck shown in Fig. 32 is seldom used for handling hand-made bricks; but is employed for carrying machine-made bricks, and is usually built of two sizes, with either open platform, as shown in the cut, or of light boards.

Fig. 32.



The open top is used for carrying bricks in the moulds, while the close platform is used for carrying them, as made ready for haking or for conveying tile. Price of either open or close pattern, No. 1, without springs, $8. No. 2, with elliptic springs, $10.

b. Setting the Bricks in the Kiln.

The bricks having been moulded and dried, the next step is that of setting or placing them in the kiln preparatory to burning, which work is generally done by task and usually by a force of five men, called the "setting gang," which is composed of one foreman called the "setter," and four men who bring the bricks to him, called the "wheelers and tossers."

A day's work for this gang is to take 20,000 bricks out of the sheds, wheel them to the kiln and toss them to the setter, who places them in a proper manner for burning.

In a kiln the first bricks set are in the back arch, and arch bricks in setting are divided into four classes, viz: the straight courses, pillar, hangers, and skintle bricks, the names depending upon the position which they occupy in the arch.

The arch is generally fourteen courses high, the bricks being set on edge and one-half inch apart; the bottom eight courses of the arch are usually called the "straight courses," on the top of which are placed the projecting six courses forming the arch, and which are called the "over hangers."

The "pillar" bricks are the ones between the straight courses, and the "skintles" are the bricks set diagonally in order to tie the over hangers together, as shown in Fig. 33*a*.

The row of bricks first set on the top of the arch is called the "tie course," and the fourteen courses, including the "tie course" first set on the top of the arch, is called the

"lower bench," and next fourteen courses, which usually finish the height of the kiln, are called the "upper bench." "Forty-two high" is the way that the height of the kiln is described, and this is the usual height.

Fig. 33a.

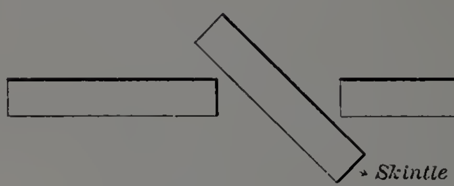


Fig. 33b.

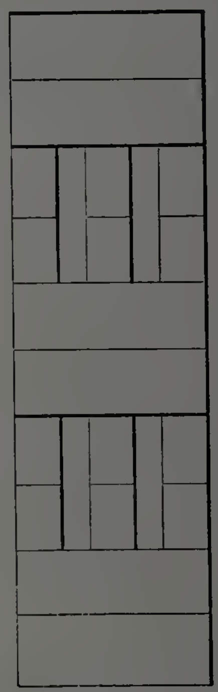


Fig. 33b shows ten courses of common bricks set on the bench in the kiln, so placed as to preserve one uncrossed face to each brick. The arch, lower and upper benches having been set, there is a brick laid flat on the topmost brick; this brick is called the "raw platting;" then on the top of the raw platting a burned brick is laid reversed way across it; this is called the "burnt platting."

It is the duty of the setting gang, in addition to placing the twenty thousand bricks in the kiln, to "platt" it, and then cover up the face of the raw bricks with boards on end; this process is called "facing up."

In this manner the kiln is "set out," or filled with green bricks, and sometimes two, three, and even four setting gangs are simultaneously at work in the same kiln, if there is a great demand for the bricks.

Before any bricks are set into a kiln, it is plastered or daubed all over the inside face with mud, in order to stop any cracks that there may be in the face of the walls, and to hold the heat when the kiln is on fire. For this work one dollar and twenty-five cents is paid for a small kiln holding one hundred and sixty thousand bricks, and two dollars and fifty cents for a kiln holding one half million of bricks. The bricks having all been placed in the kiln, the opening through which the bricks are wheeled into the kiln, and hauled out after burning, is closed or walled up.

This opening is called a "facing," "bestowing," or "abutment," and the process of walling it, "closing the bestowing."

The wall of the bestowing is built in two thicknesses of bricks; the first or inner one is put up and "daubed" or plastered over; then the second, or outer thickness, is built and "daubed." Care is taken in this operation to prevent air from entering and lowering the temperature of the kiln.

The gang that puts up, daubs, and props the "bestowing" is allowed one-half day each man.

A good setting gang can commence work at five o'clock in the morning and place 20,000 bricks in the kiln, and have their task completed by mid-day.

The bricks have now been made and set, and are ready to be burned and converted from a perishable into an imperishable substance.

c. Burning.

The high price of wood in large cities makes it entirely out of the question to use it generally for burning bricks.

The process of burning by coal is the one that we shall describe; the principle is the same as for wood, the agents employed to produce the heat being the only difference.

Brick-kilns requiring wood for fuel are flat in the bottom, and paved with bricks; coal-kilns have part of this pavement cut away under the portion which is to form the arch of the kiln, and the place filled with grates, and under each of the grates there is a trench dug all the way through the kiln, called the "ash-pit." A space at each side of the kiln is dug out to the depth of the ash-pits, the top covered with a slanting shed, and the space is called the "kiln-shelter," and serves as shelter for the laborers and fuel while the kiln of bricks is being burned. Before fire is placed in the coal kiln, the ashes made in burning the previous kiln of bricks are drawn out of the pits into the kiln shelter, thrown into wheelbarrows and carried out of the way, and after fire is started in the kiln the ashes are drawn each day.

The roof over the kiln is next examined to see that it is not leaky, and then every alternate brick which was laid flat, and called the "burnt platting," is stood upon its end, this being done in order to allow the steam, or as it is called in burning, the "water smoke," to escape as rapidly as possible.

The platting having been raised, the next step is to start a small fire in the mouth of each arch, using light splintered

wood, and building it up with lumps of coal, the fire should be started on the side of the kiln that will allow the smoke to be blown by any wind entirely through the arches of the kiln.

After the fires have been started in the mouths of all the arches on the windward side of the kiln, they are next made in the mouths of the arches on the opposite side.

The fires are built up gradually from each side until they meet in the centre of the kiln, and this is called "crossing the fires."

The fires should be "crossed" much more slowly for dry or damp clay machine-made bricks than for hand-made bricks.

When bricks produced by the hand process are well dried, and there is no dampness in the bottom of the kiln or in the ash-pits, the fires can be crossed in forty-eight hours; but for machine-made bricks they should never be crossed inside of seventy-two hours.

It should be noticed that the steam, or "water smoke" is freely coming out of the top of the kiln from the time that fire is put into it.

The fires are now increased, until the fifth day, or say, in other words, the one hundred and twentieth hour after setting fire; by this time the "water smoke" or steam from the top of the kiln should have changed from a white, watery, into a bluish-black smoke, and the fire should in the night-time be seen plainly coming through the top.

At this period the kiln is said to be "hot," and the bricks are now ready to shrink, or as it is termed in burning, to

"settle," and all the platting is put down, and tightened. Care must, to this point, have been observed to increase by degrees the heat, the firing having been gradually reduced from four hours to about two hours between fires at this stage.

The fires that the bricks are now to receive are the most intense, and the heaviest that will be applied to them; the oxide of iron is now to be converted into peroxide, or, as the men around the kiln would call it, "the bricks are to be painted red."

Before these fires are given, a long iron rod, a little longer than one-half the width of the kiln, having a flat, nearly circular piece at the one end, open in the centre, and having an iron handle at the other end, as shown in Fig. 34, is run on top of the grates and under the fires to loosen them.

Fig. 34.

The instrument is called a "moon," and its object is to enliven the fires and to get rid of the ashes, as well as to break up the clinkers.

After "running the moon" into all the arches of the kiln, they are allowed to wait, or cool, for twenty minutes or so, when the arch first mooned is fired from both sides at the same time. The amount of coal thrown uniformly through each arch varies with the condition of each particular arch. An arch that is very hot is not fired so hard as one that is cooler.

The usual amount of coal thrown into each arch in these settling fires is about from thirty-two to forty shovels full,

that is, from sixteen to twenty shovels full for each door on each side of the kiln. Before these fires are given, the doors in the ash-pits are closed, and kept closed for about five minutes after the last arch is fired; any "cold" place in the kiln can now be detected by the black smoke not freely issuing from it, which can be seen from the top of the kiln. A few shovels full of coal are now thrown into the arches under these places.

The doors to the mouths of the arches are closed soon after the fires are crossed; if an arch is too hot, the door is opened a little, which is called "cracking the door."

The "settling fires" are given to the kiln about every two hours, unless it happens that the wind and rain keep the heat down in the arches, in which cases the firing is delayed until the arches are cool enough.

After the kiln is "burned off," all the doors and all the cracks are plastered, and the kiln remains closed for five days.

If the arches are fired too hot, they will "run" or stick together. Some kilns have very high stationary roofs, others have movable roofs that slide on railroad tracks from one kiln to another; but the majority of kilns have only temporary roofs, which are taken off when the kiln gets "hot," which is, as has been stated, about the fifth day.

When the kiln of bricks has settled sufficiently, that is, sunk, the proper amount of settling is known only by experience with the clay; but for moderately strong clay, it is about seven and one-half per cent. of the height.

For instance, say a kiln of bricks is made of moderately

strong clay, and set forty-two high in the kiln, and the bricks measure four and one-half inches in width, the total height would be one hundred and eighty-nine inches, and seven and one-half per cent. would be a little over fourteen inches. Many classes of weak clays for the same sized kiln could be settled only about seven inches, and still make good building bricks.

For information as to the nature of clays the reader is referred to Chapter II., which treats of the different varieties.

The kiln which has been described in burning is the ordinary open Dutch kiln. I selected that class of kilns for describing the process because they are, unfortunately, the ones that are generally used. There are various other kinds of kilns, many of which are decided improvements, especially in the consumption of fuel.

The Hoffman, and many of the other annular kilns lose no heat and are very effective; the over or down draught kiln is also an excellent improvement.

There are other plans for burning bricks, such as by hot air, and combinations of gas and air. A kiln for this manner of burning bricks is shown and described in Chapter VI. Combinations of gas and gaseous fuels, superheated steam, and other devices, which, although they are all good, require a highly scientific knowledge of heat, its mechanical actions, and many other things.

There has never been in the past four thousand years and more, such a thing as the "science of brick-making," and there probably will never be.

The laboring men who produce bricks and other lower

classes of pottery, know absolutely nothing of the chemical properties of clay; they become acquainted with its physical peculiarities through working in it for a lifetime.

Can a person at the present time, or could he in the long past, go into the brick-yards and converse with the laborers about compounds of alumina and silica, oxide, peroxide, and protoxide of iron? Could any of them converse intelligently concerning the process of converting the oxide of iron into peroxide, and argue the question of the application of terms?

Would there be found to-day a laborer in any of the lower branches of pottery who could explain that the term peroxide should be applied to the oxide of a given base that contains the greatest quantity of oxygen, and that the peroxide of iron is a sesquioxide, the peroxide of tin a deutoxide, and the peroxide of gold is a tritoxide? The term is bad, and should therefore be changed. To make a "science of brick-making" many technical terms now very inaccurate would have to be changed, many new terms would have to be invented. Are we to have laborers who can do this?

Many of the laborers in the brick-yards are familiar with much of the above; but it is with the external manifestations. They know that clay and sand mixed will make a brick, and if the brick be hard-burned it will be of a red color.

The knowledge possessed by laborers in the production of all the lower classes of pottery has been only a mechanical idea of the materials in which they work, and it will probably be so always. "The poor ye have with you always," and so long as we have this class, we shall necessarily have the ignorant, and the brick-yards and potteries will get

their full share of the latter all the time, which will be a perpetual bar to any "science of brick-making," which a little book published in England about fifty years ago predicted there would be.

The amount of coal required to burn a kiln of hand-made bricks is usually about one-quarter of a ton to one thousand bricks; but for dry-clay bricks a larger quantity is required, the amount being about one-third of a ton to one thousand bricks, which applies in both cases to the open top or Dutch kiln, but when more economical forms of kilns are employed the consumption of fuel is much less.

The centre of a kiln settles first in burning, after which the settling fires are put close to the mouths of the arches, no coal being thrown in the centre; the fires in the mouths are called "head fires." To enliven these fires a "short moon" is used, and it is similar to the long moon described before, the difference being only in the length of the handle.

In addition to the long and short moons, another tool, called a rake, is used; it is as long as the long moon, and has teeth three-quarters of an inch in diameter, and four inches long, set into a back of iron ten inches long, two inches wide, and three-quarters thick.

Soft coal increases in bulk after being fired, and the rake is used for levelling the high places in the fire of the arches of the kiln.

A sledge hammer, weighing about ten pounds, is used for breaking up the large lumps of coal, fine coal being used for settling the kiln.

For each kiln-hand there is required a small furnace

shovel or "scoop," for firing, and in addition, two large coal shovels for general use in throwing the coal into the kiln-shelter and spreading it along in front of the arches.

A rough ladder for climbing about the kiln is also necessary, as well as two stout water-buckets in which to carry the mud, or "daub," used for plastering over all the cracks which appear as soon as the kiln commences to get hot.

It is often necessary to place a barricade of boards around the kiln-shelters, and often around some part of the top of the kiln during periods of high winds.

The time of the men around the burning kiln is divided into periods called "watches;" a watch is two days and a night, that is, a man starts to work on a kiln, say at six o'clock in the morning; he stays that day and night, and the next day until five o'clock in the afternoon, at which time he is relieved. After resting that night, he is at the kiln the next morning, and takes another watch of two days and a night; the time made at night is counted as a day extra.

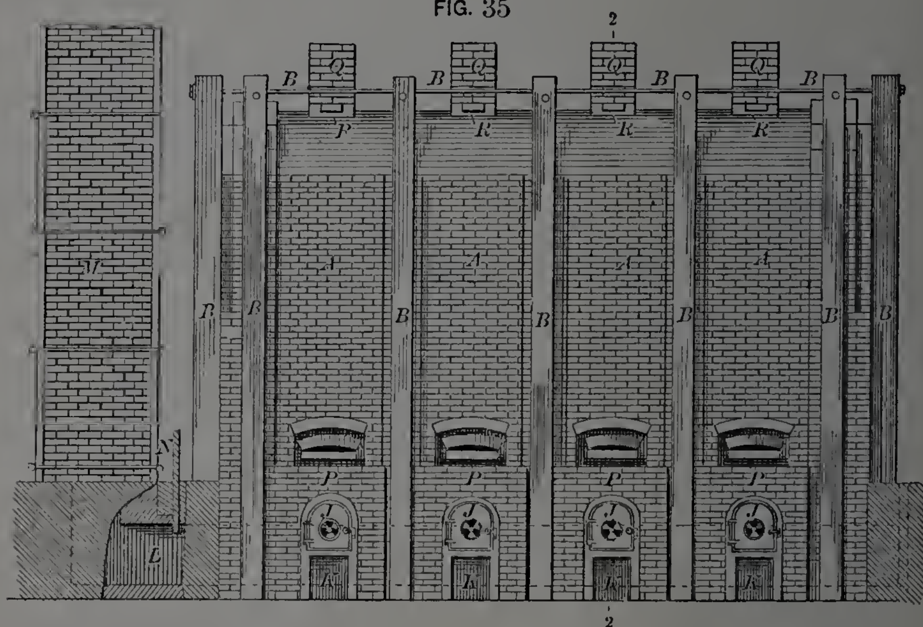
d. Improvements in constructing Permanent Kilns.

Mr. Willis N. Graves, of St. Louis, Mo., has invented a good kiln for burning bricks thoroughly and economically, and relates to those kilns which have an up and down draft, through means of suitable flues connecting with the same fire chamber or chambers, and flues beneath a perforated floor communicating with the main chimney and outlets on top of the kiln, the flues from the fire chamber or chambers

and outlets being provided with suitable dampers. The invention consists, first, in the arrangement of the flues beneath the floor of the kiln; and, secondly, in a means for preventing the products of combustion taking the shortest course from the tops of the vertical flues to the flues beneath the floor.

Figure 35 is a front elevation with a small portion of the escape-flue broken away. Fig. 36 is a vertical section taken

FIG. 35



on line 2 2, Fig. 35, showing one side of the kiln filled with bricks, and the other side empty. Fig. 37 is a horizontal section taken on line 3 3, Fig. 36, with part of the floor of the kiln broken away, to show the distributing-flues beneath.

D represents the kiln or brick-chamber, with a floor *E*, with passages *F*, forming a communication with flues beneath the floor. The floor preferably consists of tile made from fire-clay, supported on walls or ribs *G*, which form the

flues beneath the floor. (See Fig. 37.) Every fourth wall, *G*, joins with the sides of the kiln-chamber, forming one

FIG. 36

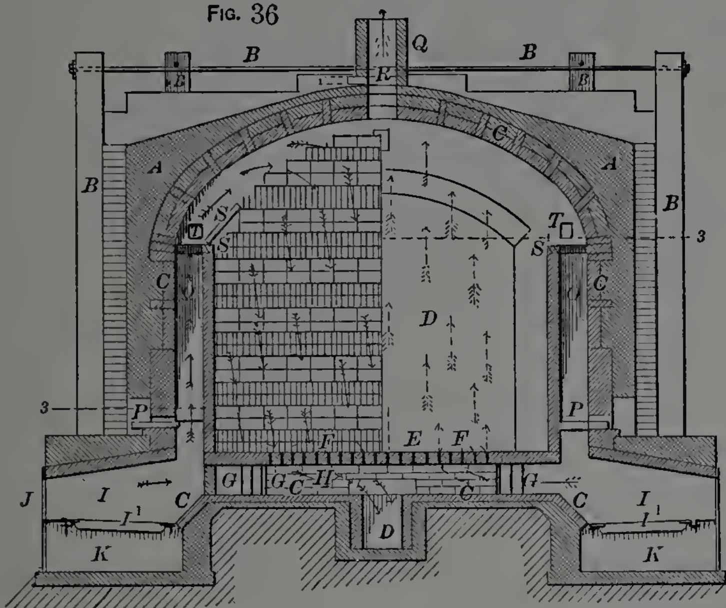
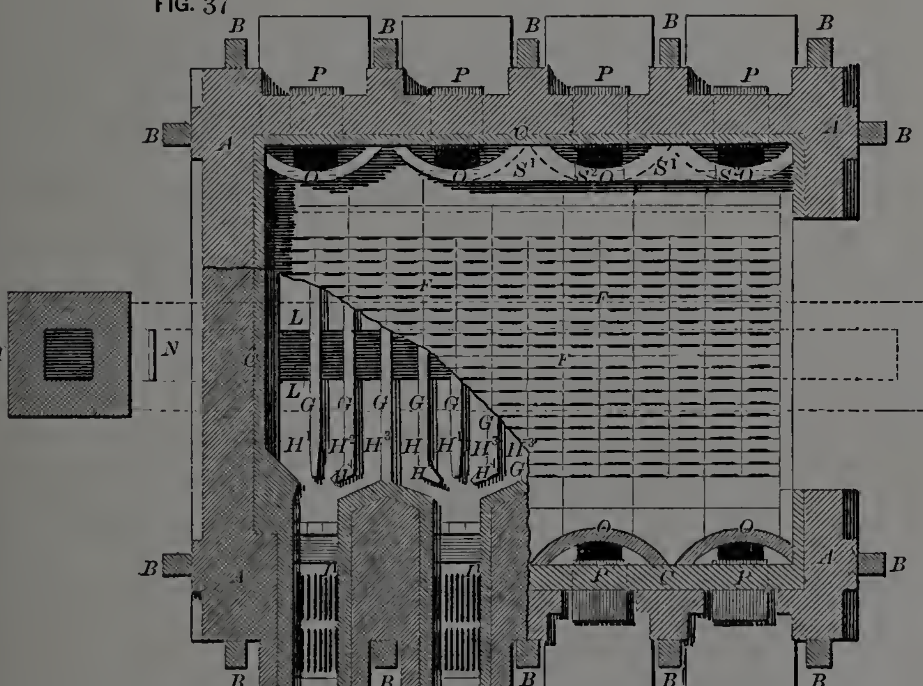


FIG. 37



main flue for each fire-chamber, or each set of fire-chambers where two series are used, as shown, and these main flues

are subdivided by the intermediate walls *G*, which do not quite extend to the sides of the chamber, as shown in Fig. 37, thus forming small distributing-flues $H\ H^1\ H^2\ H^3$. Of these three intermediate walls, the outer ones have inturned ends H^4, so that as much heat is deflected into the two outer flues $H\ H^3$, as passes directly into the two central flues H^1 H^2. We have shown a series of fire-chambers *I*, at each side of the kiln as the preferred form; but one series only may be used.

A represents the outer walls of the kiln, strengthened by ties *B*, as usual, and having the customary lining *C*, of fire-clay.

I^1 represents the grate-bars of the fire-chambers, and *J* the doors thereto.

K represents the ash-pits.

The flues $H\ H^1\ H^2\ H^3$ communicate with a transverse flue *L*, which connects with the chimney or uptake *M*. The communication between the chimney and flue *L* is regulated or entirely closed, as desired, by a damper *N*.

Each fire-chamber is provided with a flue *O*, leading to or near the top of the kiln-chamber. These flues can be closed by dampers *P*.

Q are chimneys or outlets on top of the kiln, preferably one for each pair of fire-chambers, where two series are used, and these outlets can be regulated or closed by means of dampers *R*.

The operation of the kiln is as follows: Supposing it is first desired to have a downdraft, or, in other words, have the heat and products of combustion pass from the top of

the kiln-chamber down through the mass of bricks, the flues $H\,H^1\,H^2\,H^3$ are closed by pieces of bricks and refuse matter thrown in through the fire-chambers, the dampers P of the flues O opened, the dampers R of the chimneys Q are closed, and the damper N of the chimney M is opened. The fires then being started, the heat and products of combustion will pass up through the flues O, down through the mass of bricks, through the openings F into the flues $H\,H^1\,H^2\,H^3$, and from thence through the transverse flue L to the uptake or chimney M, as shown by full arrows, Fig. 36. Then, when an updraft is desired, the flues $H\,H^1\,H^2\,H^3$ are opened by the obstruction being removed, as by means of an instrument introduced through the fire-chambers, the dampers R of the chimneys Q opened, the dampers P of the flues O closed, and the damper N of the chimney M closed. The heat and products of combustion then pass from the fire-chambers to the distributing-flues $H\,H^1\,H^2\,H^3$, through the passages or openings F, and up through the mass of bricks, escaping through the chimneys Q. The draft can thus be changed with very little trouble, as many times as desired, during the burning of a single kiln of bricks. The updraft is shown by dotted arrows, Fig. 36, on one side of the figure, the downdraft being shown on the other side by full arrows, as stated.

When a downdraft is used it is important that some means be employed to prevent the heat and products of combustion from taking the shortest course from the tops of the flues O to the flues $H\,H^1\,H^2\,H^3$, to avoid overburning the bricks next to the flues O, and to cause an equal burn-

ing of the bricks throughout the kiln. Furthermore, as the bricks are being burned they shrink, forming a flue between them and the sides of the kiln-chamber, down which the heat and products of combustion would be drawn. In order to avoid these difficulties the inventor places tiles, of suitable length, with their lower ends resting upon the upper edge of the outer walls of the flues *O*, and their upper ends resting upon the bricks, as shown in Fig. 36. Thus the heat and products of combustion are compelled to pass up over the tile before they can descend. As the tile would not rest well if placed directly upon the tops of the semicircular flues *O*, the inventor first places blocks, S^1, of fire-clay on top of the flues, covering the V-shaped spaces between the flues, as shown in Fig. 37. The inner corners of the blocks are cut off, concave shape, so as not to obstruct the openings of the flues. A common brick S^2 can be placed between the ends of the blocks S^1 to give a uniform height to the tile *S*. One of the blocks S^1 is shown removed in Fig. 37.

T represents peep-holes. (See Fig. 36.)

e. Temporary Brick-kiln.

The invention shown in Figs. 38, 39, 40, 41, and 42, which is that of Mr. Wm. H. Brush, of Buffalo, N. Y., relates more particularly to temporary brick-kilns which are set up wherever the green bricks are required to be burned, as contradistinguished from permanent kilns, which are stationary structures, and provided with fixed furnaces of various constructions.

Heretofore the fuel in temporary brick-kilns or clamps has been placed within the arches either directly upon the ground, when wood is used, or upon grates extending through the entire length of the arches. This mode of firing is objectionable, for the reason that it is not uncommonly very difficult to regulate the fire so as to produce brick of uniform color and strength.

This invention consists, first, in arranging two fire-grates within each arch, one near each end thereof, leaving an intermediate space for fuel to be placed directly on the ground, so that the combustion of the fuel in the space between the grates can be regulated by the fire upon the latter, and air-currents above and below the same, as will be more fully explained; second, in arranging a hinged apron on the under side of each grate for the purpose of preventing the cold air from entering the arch, and permitting access to the fuel in the space between the grates when required; third, in the combination of the grates, fuel-space, hinged aprons, and fire-doors, provided with deflecting-plates, whereby the fires are perfectly controlled and readily directed to any portion of the arch without admitting cold air into the latter.

In the drawings, Fig. 38 is a sectional elevation, showing an arch of a brick-kiln provided with these improvements. Fig. 39 is a plan view of two arches. Fig. 40 is a front view, showing one arch in front elevation, and one in cross-section. Fig. 41 is a rear view, and Fig. 42 a horizontal section, of the fire-door.

A represents the arch of green bricks set up in the usual

manner. *B* are the frames of the fire-doors, arranged in the outer walls of each arch in the ordinary manner. *C* is a fire-grate, preferably about five feet in length, arranged within each arch at each end thereof, as clearly shown in

FIG. 39

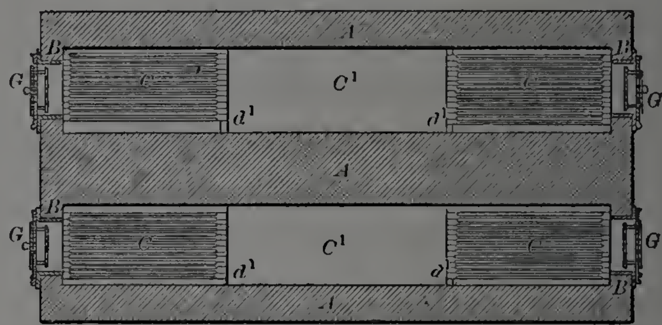


FIG. 38

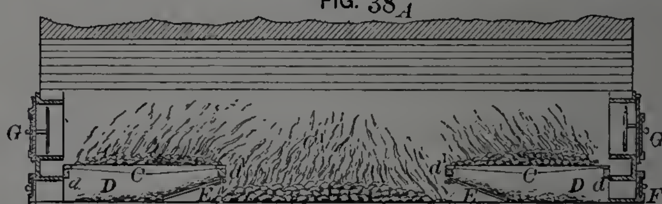


FIG. 40

FIG. 41

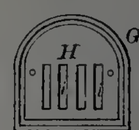
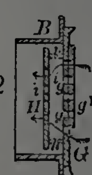


FIG. 42



the drawing. The grates *C* are supported upon bars *d* d^1 resting upon the bricks of the ash-pit *D*, which latter is preferably composed of old or burned bricks. *E* is an inclined plate or apron hinged or hung to the rear grate-bar d^1, as clearly represented in the drawings, and made of the same width as the ash-pit, so as to prevent the cold air in the ash-pit from entering the arch, except through the burning fuel

upon the grate *C*. The aprons *E* incline toward the ash-pit door *F*, so as to cause the ashes and cinders dropping upon the aprons to slide forward toward the ash-pit door, and the hinging of the aprons to the grate-bars enables the front ends of the aprons to be raised, so as to permit access to the fuel placed upon the ground between the grates *C C*.

G is the fire-door, hinged to the frame *B*, and provided with vertical slots or openings *g*, which are opened and closed by a sliding plate g^1, in the manner of an ordinary register.

H is a protecting-plate, arranged on the inner side of the fire-door *G*, and connected thereto by stay-bolts *h* in the usual manner. *i* are vertical slots or openings, arranged in the plate *H* in such manner that solid portions of the plate *H* are opposite the openings *g* of the fire-door *G*, and the openings *i* opposite the solid portions of the fire-door. This construction of the protecting-plate *H* causes the air-currents entering through the openings *g* of the fire-door to impinge against the solid portion of the plate *H*, which, being kept at a very high temperature by the fire upon the grate, heats the air before it enters the arch, thereby preventing the bricks from becoming checked.

The grates *C* may be charged with wood or coal, and the space C^1 between the grates is preferably charged with wood or coke. By admitting a strong air-current through the fire-doors *G*, the flame and hot gases are driven from the grates *C* toward the centre of the kiln, and the combustion of the fuel between the grates is accelerated. Upon closing the damper in the fire-door *G*, the hot gases from the grates

C rise perpendicularly through the arch, and the combustion of the fuel between the grates is retarded. Upon raising the ends of the aprons *E*, the ashes can be raked out from the space between the grates, and new fuel can be supplied thereto without interfering with the fuel upon them, while, by supporting the front ends of the aprons in a greater or less elevated position, the combustion of the fuel in the space between the grates can be regulated without affecting the combustion of the fuel upon the grates.

It is obvious from the foregoing that these improvements, which are readily and cheaply applied to kilns of ordinary construction, give a perfect control over the fires in all parts of the arch, thereby enabling the bricks to be burned to a uniform color and strength, and preventing loss from checked bricks.

The entire fire-surface being arranged within the arch the heat developed by the fuel is fully utilized, and loss from radiation, while not of course fully prevented, is to a great extent curtailed.

Section VII. Improvements in Kiln Roofs.

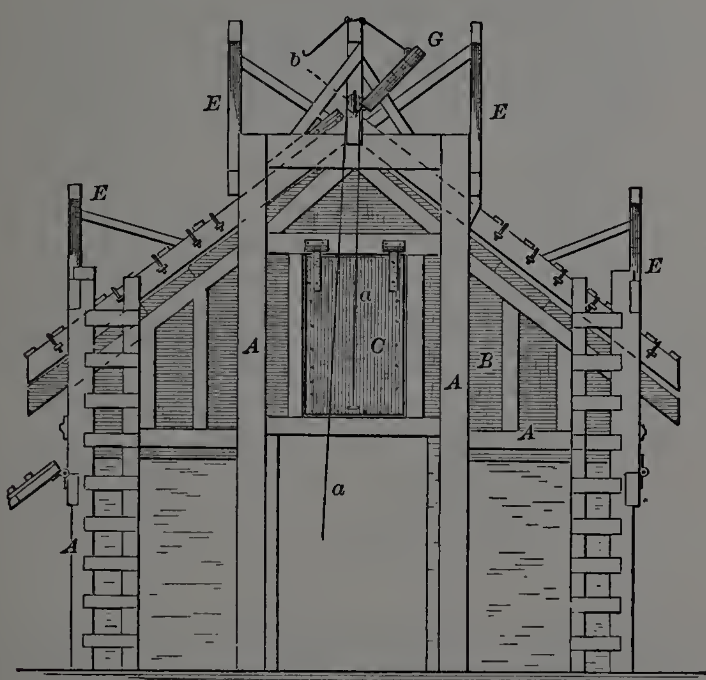
The kiln roof shown in Figs. 43, 44, and 45 is the invention of Mr. Thos. F. Adams, of Philadelphia, Pa., and it is in use at the works of the Peerless Brick Company in that city, which company controls the patent right,

The roof is permanent on the kiln, and enables the burner to manage the direction of the heat, and by closing and opening the doors he can create a draft at any part of

the kiln he may desire. By having the roof permanent, a great saving of labor in taking off and putting on an ordinary wooden roof is effected, and the waste incident to the repeated handling of the boards is obviated. It renders the brick-maker independent of the weather, as his kiln is covered at all times, and the doors can be shut down more or less during a storm. It saves fuel, as the heat cannot escape so rapidly, and the proportion of hard-burned brick is largely increased, and a much greater uniformity of color throughout is secured.

Fig. 43 is an end elevation of a brick-kiln embodying this

Fig. 43

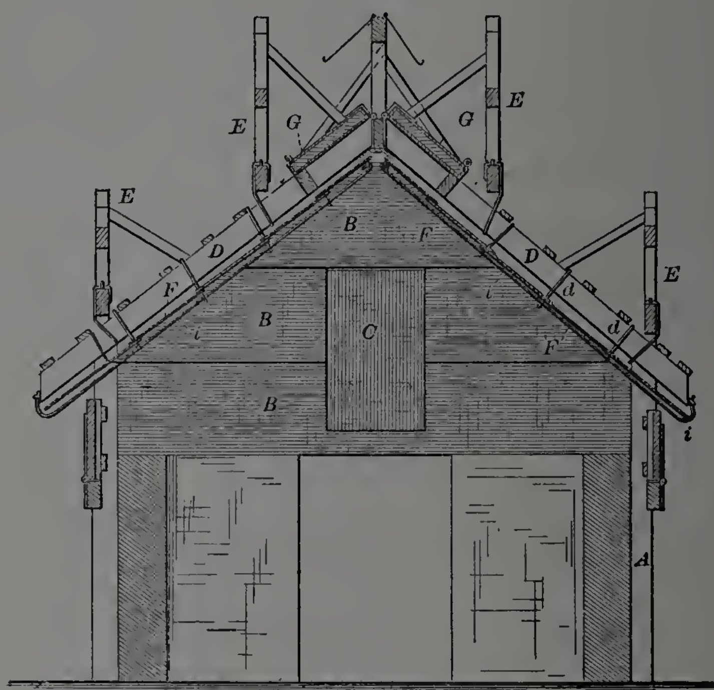


invention. Fig. 44 is a transverse vertical section of the same. Fig. 45 is a detail view of a part thereof.

A represents the ordinary frame-work of a brick-kiln, which is boarded up to a certain height. At each end are

then applied sheets *B B*, of iron, to complete the gable, and in the same is made a door *C*, which is hinged at its upper end, and provided with a chain *a*, passing over a pulley *b*, at the top of the frame, so that the door can be opened more or less from the ground, as may be desired.

Fig. 44



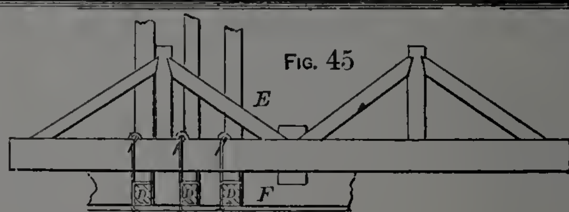


Fig. 45

To the frame-work *A* are connected suitable upright truss-frames *E E*, standing above the kiln on each side, and to these are secured rafters *D D* on each side, the rafters meeting at the top in the centre, and sloping downward on each side below the truss-frames.

The roof of the kiln is composed of iron sheets *F F*,

which are suspended from the rafters by hooks or stirrups *d d*, passing through the sheets and fastening in rods *i*, running from the top to the lower edge of the roof on each side.

At the top, in the roof thus formed, are made hinged doors *G G*, to be opened more or less, as occasion may require.

The iron roof *F* is suspended about an inch below the rafters, so as to prevent any liability of the wood catching fire.

CHAPTER V.

BRICK-MACHINES.

The Manufacture of Bricks by the Machine Process.

THE enormous demand for bricks, in highly civilized countries, has vastly stimulated the invention of all classes of machinery to save labor, and to produce quickly large quantities of moulded bricks from crude clay, in all conditions of plasticity, as well as in all stages of dryness.

All brick-machines may be divided into two classes: The first embracing those that employ moulds, into which to force the clay to a shape; the second class being those machines which shape the plastic clay by forcing it through an opening or die in the pug-mill, and in a continuous string, which is afterwards cut into bricks of the required size, either by a revolving knife, or by wires attached to a frame.

To the first class belong all dry and moist-clay machines, as well as the slush-machines; to the second class belong only the wet or plastic-clay machines, as dry, moist, and slush-clay could not hold a good form after passing through the opening or die, and during the process of cutting them into shape.

The first class includes a very large number and great variety of machines, and with the exception of the dry-clay

machines, they are a valuable line of inventions. The second class comprises but few, comparatively, in either number or variety of styles.

The stock produced by the first class of machines is usually better formed, cheaper, and suitable for architectural constructions; but while the bricks produced by the second class may not be so regular in shape, nor quite so cheaply made, they are at times preferable for purposes of engineering constructions, and are at all times desirable for building.

For instance, take the bricks made from dried clay, burned to the very hardest state, and pave a section of the invert or bottom of a sewer, through which pass quantities of sand or gravel, and then pave an adjoining section with bricks made by one of the second class of machines, and which have been burned in the same kiln with the first named bricks. What will be the result? The first section of the sewer bottom will, in a few months, be completely cut out, and the second will stay for many years in almost as good a condition as when first laid.

Many large and costly works have been greatly injured through the employment of bricks for sewer inverts made by dry-clay machines.

A case now comes to mind in which a large sewer, 20 feet in diameter, in Washington, D. C., was built of bricks made by dry-clay machines, and the material was completely cut out of the centre of the invert, and thereby let fall a section of more than seven hundred feet in length, and causing the utter destruction of that much of the work.

The first class of machines may be termed compressive, and the second class expressive machines. The pressure in the first class is given either by the cam, the toggle-joint, the combination of inclined plane and press-wheel, or the screw; in the second class, the clay is usually tempered and packed by a screw, and expressed by the piston, screw, or rollers.

The U. S. Patent Office classifies all brick and tile machines as either reciprocating or rotary machines, and manufacturers as well as engineers who operate them often classify them as either upright or horizontal machines.

There is too much ignorance displayed in regard to the material produced by this line of inventions, and which enters so largely into the construction of buildings, and this lack of knowledge is often shown by those who ought to know better.

In the desire to get up a showy house, "something that will take, you know," mistakes are too often made, and which are usually paid for by the loss of health, and sometimes by the sacrifice of life. Is it difficult to call to mind houses that people call "unlucky places," in which an unusual number of persons die?

These "unlucky places" are for the most part nothing more nor less than damp houses, resulting oftentimes from the employment of porous bricks in the construction of the walls.

A pile of bricks now presents itself to my mind which were hacked about twelve feet high, and placed on an elevation and covered with a close, tight roof, through which no water could get to them. But the bricks commenced

to get wet from the bottom, which ascended gradually to the top of the pile, and finally every brick was as wet as if it had been laid in water and soaked.

Bricks absorbing more than eight ounces of water should not be allowed in the foundations or exposed walls of dwellings. A simple way to test the absorption is to weigh the brick, and then place it in a bucket of water for five minutes or so; if it weighs more than eight ounces over its first weight, discretion dictates its rejection for the two purposes named. This test applies only to hard-burned bricks, not to salmon stock.

Architects should be aware also of the acoustic effects which dampness of walls has upon public buildings by conducing to a very great extent to reverberation, which confuses sound.

It is not uncommon for buildings to be hastily constructed, and the internal coats of plastering put on one over the other in rapid succession, and at once occupied for public purposes.

But for many months they fail to give satisfaction to the extent that had been hoped from the pains which had been taken to make them acoustically good; although gradually, as the walls part with their dampness, acoustic defects disappear.

It is of great importance that bricks used in such walls be not so porous as to constantly absorb moisture, and for a long period, or permanently, retard the drying out of the walls, or halls for public speaking or for music. While they may be good in other respects they may fail in this.

In this matter architects owe a duty to themselves no less than to their clients and the public. It is not the province of this volume to attempt an explanation of this phenomena, which is a matter of common observation.

In newly completed buildings a little drapery hung up for a few months may often retard reverberation and be a great aid; it can easily be removed when the moisture disappears from the walls, and the acoustic properties are assured.

Since dry structures cannot be built with bricks that are very absorbent, and as the extent to which bricks absorb water is so important, it is worth while to give a little attention to this subject in the different classes of brick-machines.

The bricks produced by all dry-clay machines absorb much more water than do those produced by any of the other machines.

It is not the intention in this work to canvass and give the merits or demerits of any particular machine; but by saying what has just preceded, merely to hint at a few of the considerations which should govern those who part with their money for the purchase of either the stock produced, or for a machine itself.

The process of manufacturing bricks by machinery may be divided into five stages, viz:—

Preparation of the clay.

Shaping the brick.

Drying.

Setting.

Burning.

The clay is not dug in the winter and exposed as for

hand-made bricks; but for dry and damp-clay machines the clay is taken directly from the bank, and for dry-clay machines is hauled under large sheds and allowed to dry; but for the damp-clay machines it is hauled directly to the mill which is to prepare it for the brick-machine. The difference between dry and damp-clay bricks is in the condition of the clay when it is granulated and moulded.

It requires a much stronger machine and greater power to shape the dried clay into bricks than it does for the damp-clay, as the pressure must be tremendous in the first case, and it need be but normal in the second condition, provided the pressure is exerted while the mould-bed is at rest.

Disintegrating mills for clay may be divided into two classes, the first being those which granulate and sieve the clay at the same time; and the second class being those which granulate without sieving. Sometimes there is a combination of the whole of the latter class with some portion of a mill of the first class; but the result of the combination is usually a mill of the first class.

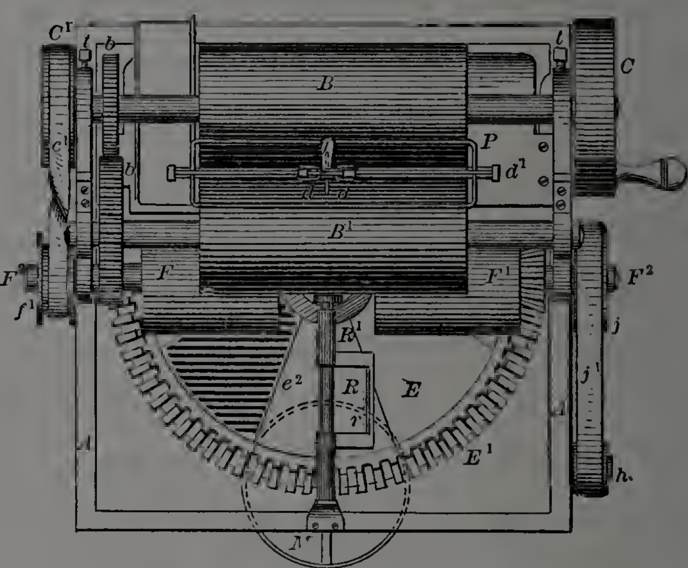
A combination of the two principles is made when the rolls are placed in position above the grates of the mill, and instead of the clay being pulverized and forced through the grates by a heavy revolving roller, the clay passes through the elevated and stationary rolls, falls upon the fixed grates, and is agitated and forced through them by revolving clay-ploughs, drags, and other contrivances.

Sometimes, as is shown by the drawings of the clay-pulverizing machine, which will be immediately described, the clay passes through the rolls and the grates are made to

revolve, and the clay falling upon them and coming in contact with the fixed irons extending over the grates, is forced or sieved through them.

The machine shown in Figs. 46, 47, 48, and 49 is in daily use in a large brick-yard in Washington, D. C., and is the invention of a practical brick-maker of that place, and it

FIG. 46



is for pulverizing clay for making brick of the kind known as "damp-clay," but by a slight modification, which will be described, it may be made to temper the clay after it has been pulverized.

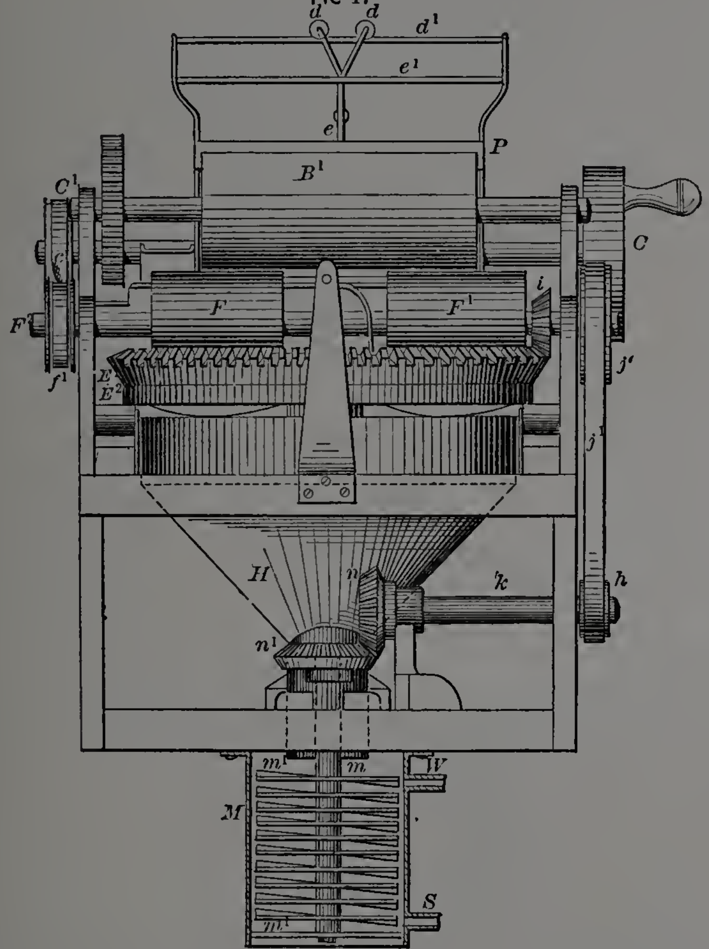
In Fig. 47 the teeth of the revolving grate E^1 are shown too close to the grates, and it was found that they were liable to clog with the clay from the grates; but this was obviated by increasing by six inches the height of the rim E^2 over that shown in the drawings.

Figure 46 represents a plan or top view of the machine; Fig. 47 a front elevation; Fig. 48 an end elevation; Fig.

49 a sectional view of the crushing-rollers and device for removing gravel-stones from the same.

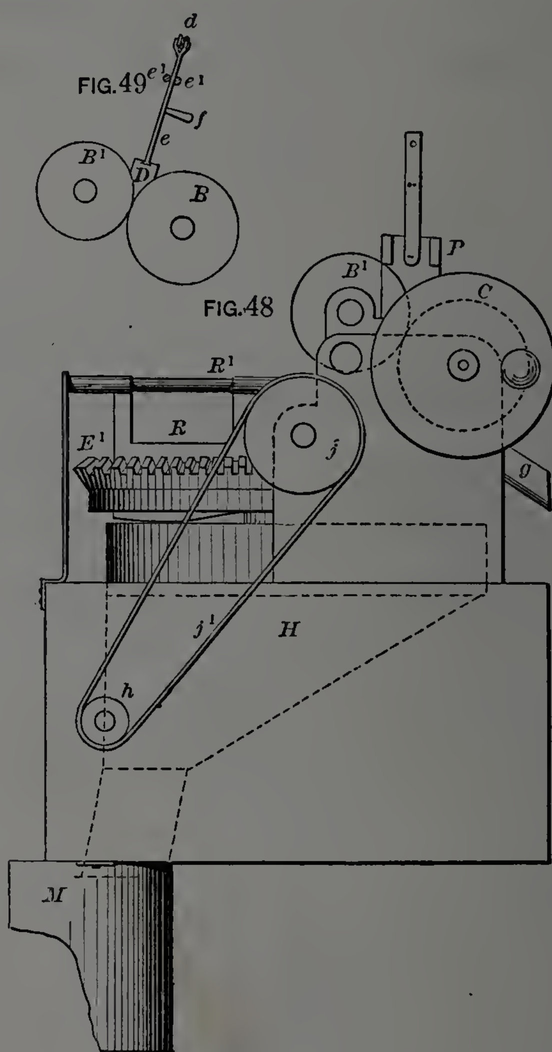
A is a box or frame upon which the main portion of the machinery is mounted. *B* and B^1 are two cast-iron crushing-rollers, made to rotate toward each other by gear-wheels *b b*.

FIG 47



The machine may be driven by any suitable power applied to the crank-wheel *C* on the shaft of roller *B*. *D* is a pointed scraper for removing stones which are too large to pass through the crushing-rollers. It is suspended from friction-wheels *d d*, which ride upon a horizontal rod or bar, d^1, above the crushing-rollers; its shank *e* passes between

two guiding and steadying rods e^1 e^1, and it is moved back and forth by the handle f to remove the stones and deposit them in a spout g.



E is a horizontally-revolving grate, consisting of a very strong wheel, with radial arms supporting the circular cog-gear E^1 and the grate, made in sections, one section of which, e^2, is shown in the drawing. The interstices between the grate-bars the inventor prefers to have about one-fourth of an inch wide. F and F^1 are two cast-iron rollers loosely mounted on a shaft F^2, and lying upon the revolving grate.

These rollers have a play of about one inch on their shaft, which allows them to rise and fall accordingly as the quantity of clay under them may vary. On the end opposite to the power-wheel C of the shaft of roller B, is mounted a band-wheel C^1, with a band c^1, passing around this wheel, and also around a band-wheel f^1, on the shaft F^2, rotates the shaft, and the pinion-wheel i mounted thereon, and engaging with the circular cog-gear E^1 of the revolving grate, rotates the grate. On the opposite end of shaft F^2 is mounted another band-wheel j, and a band j^1, passing around the wheel, and also around a small pulley-wheel h, on shaft k, rotates the shaft and the bevel-wheel n mounted on its inner end. This bevel-wheel n, engaging with a similar bevel-wheel n^1, on a vertical shaft m, rotates the latter rapidly. This shaft m is provided with a number of projecting arms m^1, which are inclosed in a cylinder M (shown in vertical section, Fig. 47), which is called the "temper-cylinder." H is a hopper for conducting the clay, as it falls through the revolving grate, down into the temper-cylinder. S is a pipe for conducting steam into the lower part of the temper-cylinder, and w is a pipe for conveying water into the upper part of the same when desired. The rollers B and B^1, and F and F^1, are each provided with stationary knife-scrapers (not shown in the drawings), to clear them of adhering clay. The rollers B and B^1 should ordinarily be adjusted so as to leave about one-fourth of an inch space between them, but by means of adjusting screws t t said roller B may be slightly moved to and from its fellow B^1.

The inventor does not desire to limit himself to the exact

proportions shown in the drawings, nor to any specified dimensions or weight of any of the parts; but I will here state what are regarded as about the proper dimensions and weight for the principal parts, viz: Crushing rollers from one and a half to two feet in diameter; and they may be both of a size, or one may be somewhat larger than the other, as shown in the drawings. They may be geared to revolve at the same velocity, or at different velocities. These rollers should be of the hardest, chilled cast-iron. The rollers $F F^1$ may be from one and a half to two feet in diameter, and should weigh from four hundred to five hundred pounds each. They should also be made of chilled cast-iron. The annular grate should be about three feet in width from the centre pedestal to the circular gear, and the rollers $F F^1$ of corresponding length. The temper-cylinder M may be about three feet in diameter, and from three and a half to four feet in depth.

R is a serrated scraper or agitator to loosen up the clay upon the grate. It is suspended from the shaft R^1, which turns upon journals, thus operating as a hinge. The points of the teeth r must be bent upward, so that they will not catch upon the grate-bars. One or more such rakes may be employed. P is a hopper, into which the clay is placed, to be fed to the crushing rollers $B B^1$.

The operation is as follows: The clay, as it is dug from the bank, is deposited in the hopper P, whence it passes through the rollers $B B^1$, becoming partially pulverized, and falls upon the revolving grate, where it is further crushed and pulverized by the rollers $F F^1$, and is forced through

the grate into the hopper *H*, and conducted thence to the temper-cylinder *M*, where it is further operated upon by the revolving arms of the shaft *m*, and finally drops out of the open bottom of the cylinder in proper condition for making bricks.

A jet of steam introduced through the pipe *S* moistens the clay slightly, so that it will the better adhere when subjected to pressure in the moulds. If it is desired to temper the clay, as well as to pulverize it, a bottom must be applied to the temper-cylinder *M*, having an opening at one side for the tempered clay to escape, and instead of introducing steam through the pipe *s*, water must be introduced through the pipe *w*. A movable bottom may be provided, which can be applied to the cylinder *M*, and fastened thereto by screws or clamps, when it is desired to temper the clay.

In reducing hard marls or rough strong clays, such as fire-clays, it is common to employ iron rolls, composed of separate pairs of cylinders, placed one above the other, and set at different openings, through which the clay passes, and these mills, which are also very valuable for disintegrating common and pressed brick clays, will be described in Chapter VI.

The clay having been properly granulated, it is now in a condition to be fed to the machine, and be shaped into bricks.

Very often the clay does not fall directly into the machine, but drops below the mill, and is carried to a point above the brick-machine, when it is then dropped into the machine through a chute. The contrivance used to perform this work is called an elevator, and the manner in which it is made depends greatly upon the quantity of clay that it is to elevate.

A good elevator for clay, when the quantity of bricks produced does not exceed thirty-five thousand in a day of ten hours, is made by using double-ply best oak-tanned leather belting, 6 inches wide, to which the buckets for raising the clay are riveted, the rivets passing through the bucket and belt, and also through a piece of light hoop-iron one inch wide on the opposite side to the bucket, and well riveted.

The buckets should be strongly made of one-eighth inch sheet-iron riveted at the ends. These buckets are wedge-shape, six inches deep, and seven inches wide at the top. The iron of which they are composed should be in one piece.

Fig. 50 shows an elevator belt conveying the prepared clay from a pair of rolls to the brick-machine, the clay falling from the mill into the buckets through a chute. When the quantity of clay to be elevated is for machines producing from fifty to one hundred thousand bricks daily, the buckets are made of stout boiler iron, and are eighteen inches long, and nine inches wide at the top.

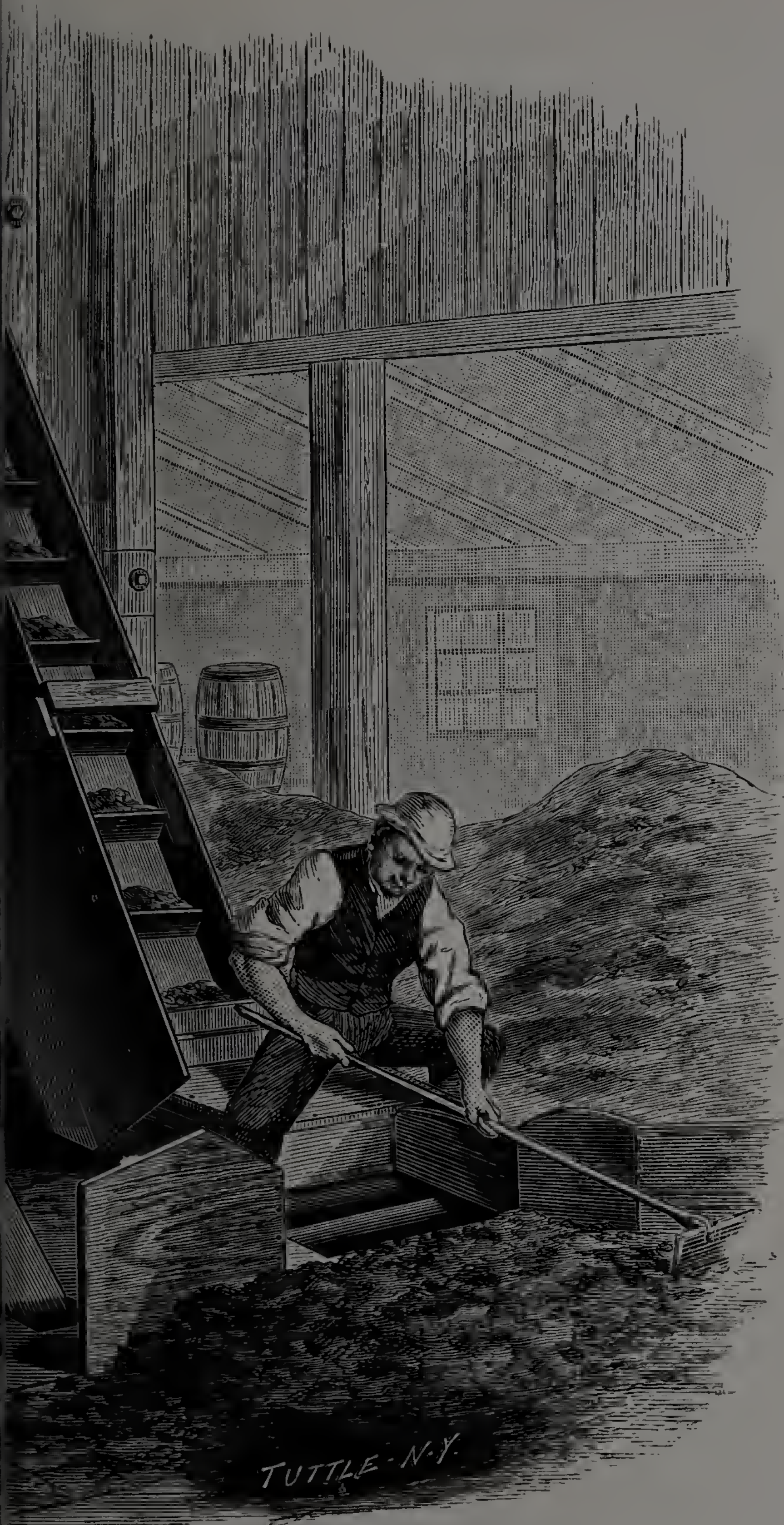
They are strongly attached to an open link chain, which is spaced so as to work the links over a cogged pulley at the top and the bottom of the elevator.

The links of the chain are rectangular, and each cross-bar is covered with a hollow roller, in order to lessen the friction.

These elevators are very efficient; one of them at work in a large brick-yard in Washington, D. C., elevates the crude clay to the mill, which prepares the material for about one hundred thousand bricks daily.

The clay in this yard, before being fed to the machine, passes through a pair of rollers, then through a mill, in

FIG. 50. MILL FOR PREPARING THE CLAY, A



ELEVATOR FOR CLAY AT WORK.—Page 176.

which a large number of steel teeth are fastened into two heavy toothed, circular, cast-iron platforms, the teeth of which interchange and revolve in opposite directions. The mill works the clay in a very damp condition, and the work of preparing it is most thoroughly done.

It would not be possible to give a detailed description of all the different kinds of brick-machines now at work satisfactorily in this country and in Europe; but the machines which are selected for explaining the modes of converting clay into bricks, although no intention is meant to give them prominence over a large number of equally good inventions, are excellent examples of the intelligent inventive genius of the age.

The entire principle of manufacturing bricks from dried clay is an error. In the first place, it is not possible to construct a dry-clay machine that will exert the tremendous pressure necessary to be continually given, and last for any reasonable length of time, without making it not only clumsy, but so expensive as to be entirely out of all proportion to any possible saving that could be made from this manner of forming the bricks. The time lost in "breakdowns" and increased cost of repairs necessary for this class of machines, as well as in the burning of the bricks thus made, is also against the dry clay system.

It is impossible to fill the charge-boxes, or as they are also termed, the "filler-boxes," with any degree of regularity in dry-clay machines, and when graduating measures are used the same difficulty is met. The moulds depend upon the "filler-boxes" for their charge of clay, and it not being

uniformly filled into them they cannot correct it in the moulds. Should the moulds be grouped together, then the work of filling them regularly becomes an impossibility; hence those receiving the least quantity of clay receive also the least amount of pressure, and the clay is but partially developed into bricks. The stock may have a uniform appearance as to density when it comes from the machine, and have a clean, attractive appearance; but the bricks are neither used, nor are they sold in this condition; they must be burned. Let us take a look at them after they have passed through the kiln; their whole appearance has changed; the bricks, which before seemed to be close and strong, are now open and weak, the separation between the particles of clay is plainly observable, and if two such bricks are struck together the sound will resemble the unringing one of two soda crackers being hit one upon the other. The moisture being extracted from the clay, and the bricks having been slighted in the pressure, complete vitrification or fusion of the particles cannot take place in the process of burning, and the result is that the bricks made in this way are very porous, absorb water in great quantities, and upon exposure readily disintegrate with the action of the elements. Having experimented largely with dry-clay machines, but knowing "their weakness, their evil behavior," it is not possible for me to say one word in their favor, and I shall pass them by without description. The machines which we shall now consider are those which accept and work the clay in a moist condition.

The machines which are portrayed in Figs. 51 and 52

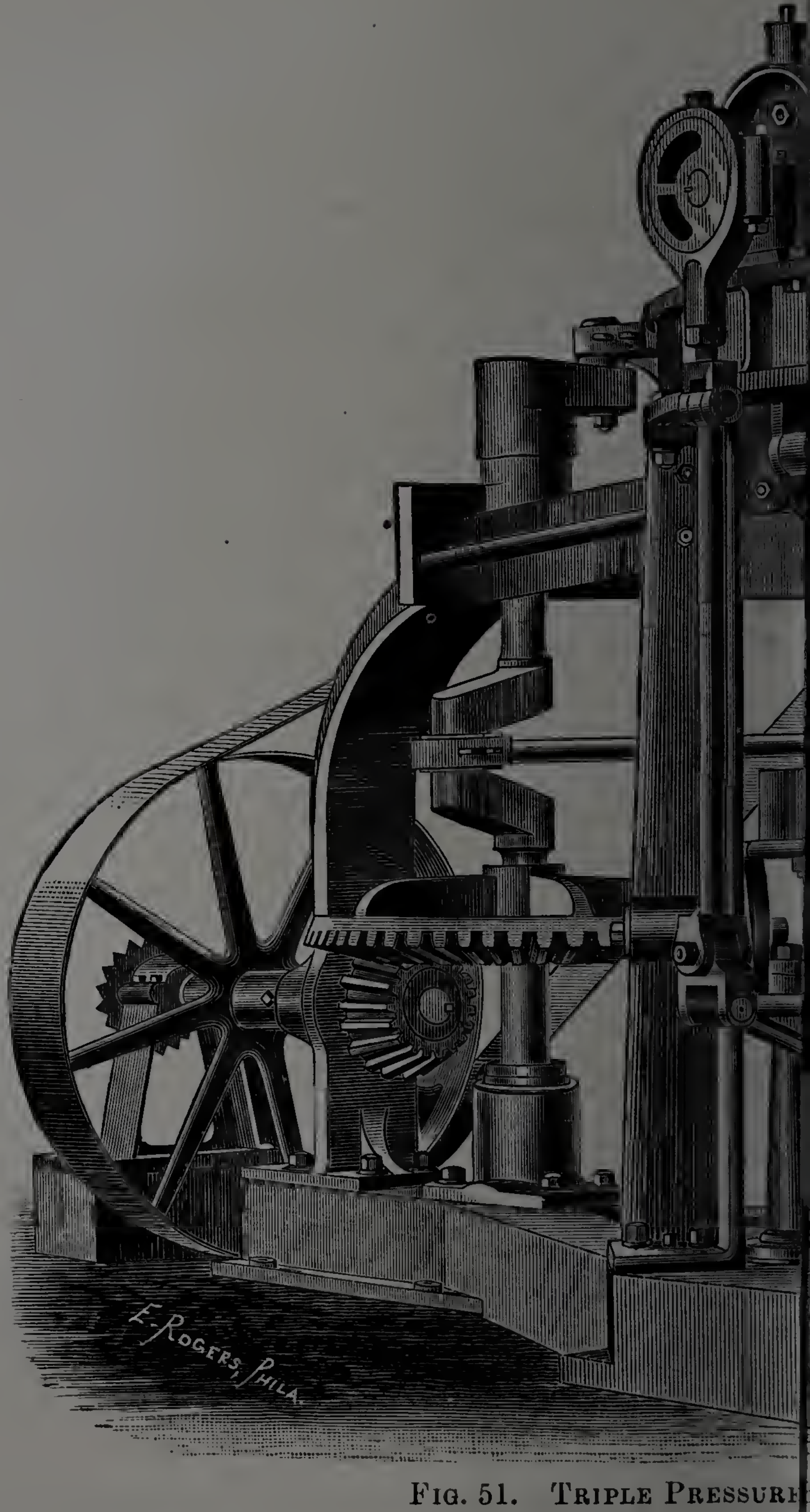
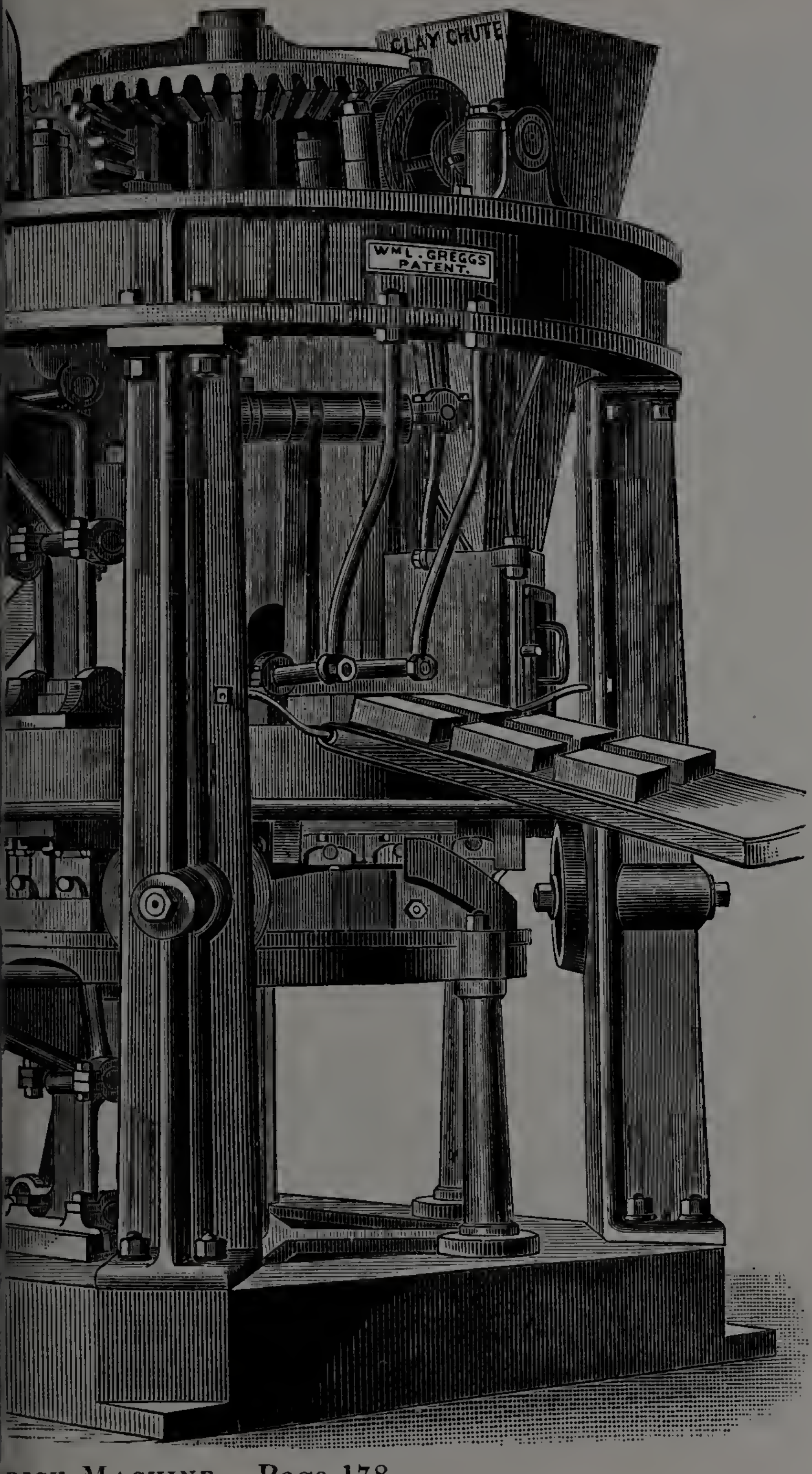


FIG. 51. TRIPLE PRESSURE



RICK MACHINE.—Page 178.

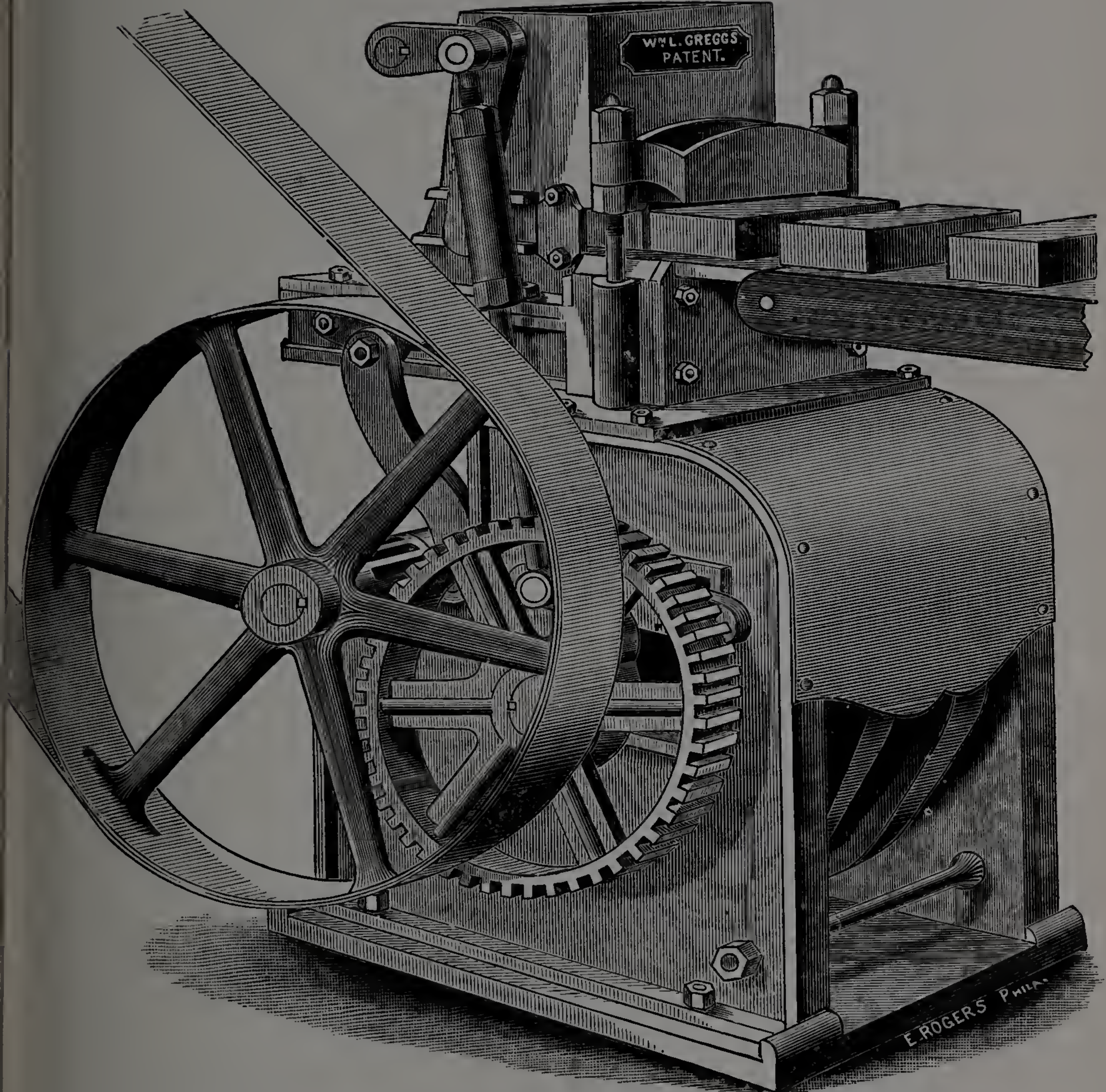


Fig. 52. No. 2 Machine, for Making and Re-pressing Front Brick, and Ornamental Brick.—Page 179.

occupy a medium position between the dry-clay machines and the tempered-clay machines. These machines will receive the clay in a stiff state, containing about four hundred pounds of water to the thousand bricks to be evaporated, and manufacture it into a good quality of building bricks. The principle of applying the pressure is by the cam; but the mechanical plan and construction of these machines is such that the heavy developing pressures take place while the mould table is at rest. The power required to operate them is normal; the strain, wear, tear, breakage, and propelling power are below the average. The clay is uniformly fed to the machines, and receiving the pressure in a moist condition the bond between the particles is good, and as these particles are drawn closer in the fusion or burning the bricks are not very porous, but are strong and absorb but little moisture.

The machine shown in Fig. 51 is the Gregg triple pressure brick-machine; it has a capacity of from twenty-five to thirty thousand bricks per day, of ten hours, which depends upon the power and the speed at which it is run. The weight of this machine is about five tons, the cost is five thousand dollars, and the cost of the disintegrating mill, which prepares the clay for the machine, is about one thousand two hundred and fifty dollars.

The power required to run both the machine and the mill is thirty-five horse.

The machine shown in Fig. 52 is by the same maker as that shown in Fig. 51; it is called the No. 2, and can be used for making from eight to ten thousand common bricks

per day of ten hours; it gives two pressures to each brick, and can be used also for making front and ornamental bricks. The cost of this machine is one thousand five hundred dollars; that of the smaller disintegrating mill used with this machine is five hundred dollars. The weight of the brick-machine is about one ton, and the power required to run it and the disintegrating mill is twelve horse.

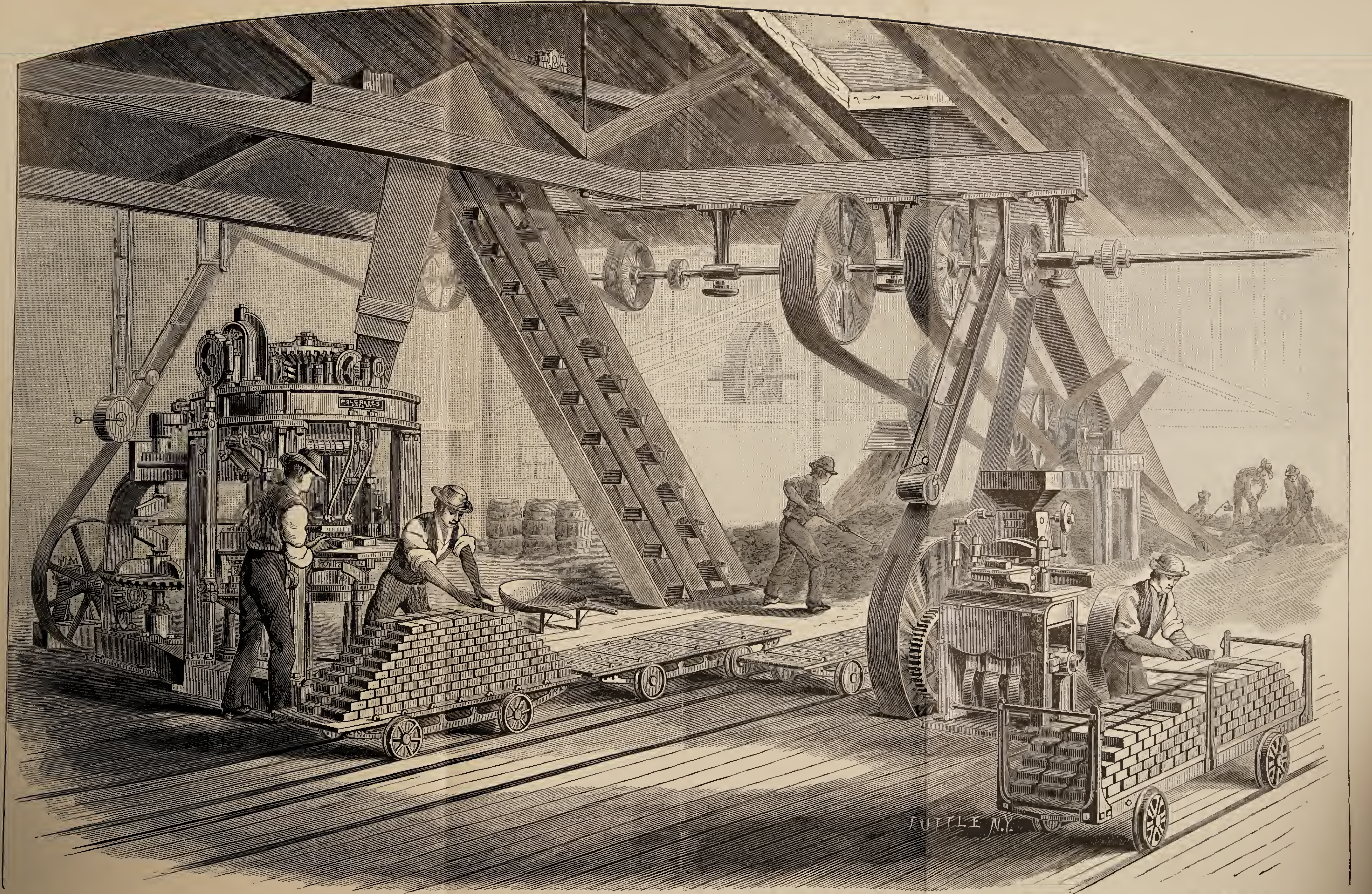
In small works the bricks made by machinery are usually placed upon a wheelbarrow, taken to the shed, and hacked, and, when dry, are again placed upon the barrow, and wheeled to the kiln.

A great saving is made by off-bearing the bricks upon low iron cars, with perforated bottoms, which are easily and rapidly moved upon tracks to the drying-room, and from thence to the kiln.

In all large works this is the method employed, as it saves a very great expense for labor, and the green bricks are not so liable to be injured or broken, and in the kiln they hold a better shape, after being thus dried.

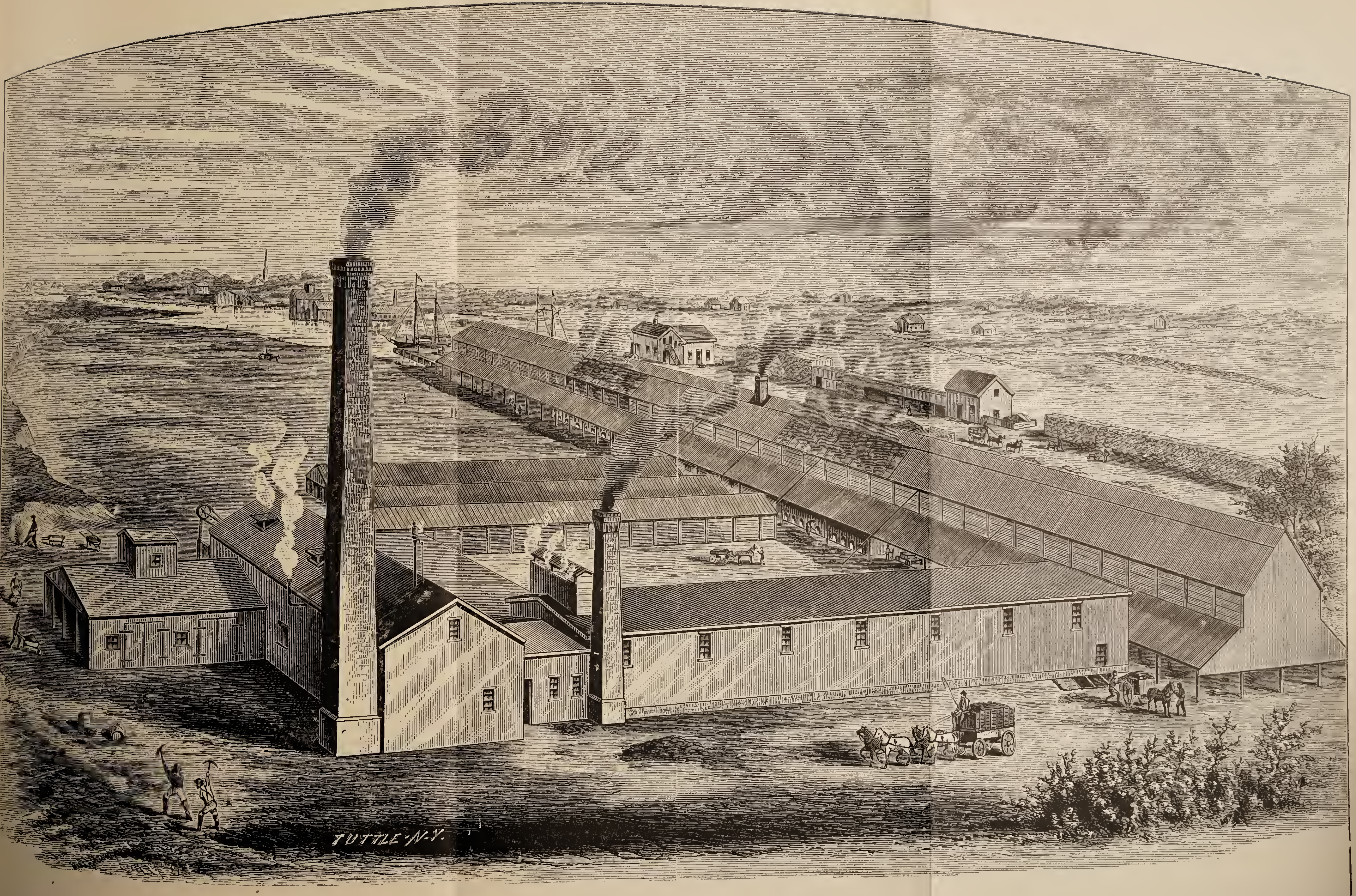
In some works the bricks are hacked edgewise four courses high, each course containing three rows of fifty bricks, thus making six hundred bricks for each car; but unless the works are very large, and some compensating gain is made, it is much better to use smaller cars, and it is preferable to place the bricks flatways, as shown in Fig. 53. Small cars have to be moved oftener, but it requires less help to change them, and there is not the same strain upon the cars and damage to the bricks.

Fig. 53 is an inside view of a machine house, and shows



Brick Cars. Clay Elevator. Brick Car.

Triple Pressure Machine. Fig. 53.—Page 180. No. 2 Machine, Re-pressing.



Engine House. Machine House. Drying Sheds. Kiln Sheds

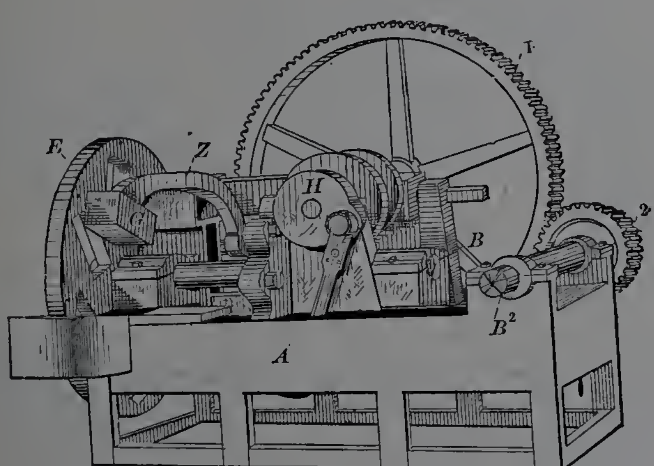
Fig. 54.—Page 181.

the Gregg triple pressure brick-machine, the No. 2 machine, and the elevator for clay at work; also two different styles of brick-cars being loaded, which are to be run upon the tracks into the drying-room. The line shaft for brick-machines should be placed overhead, as it is seen in Fig. 53, it being much easier to watch the belts which drive the brick-machines, mill, and clay elevator, than it is when the line shaft is under ground, and the belts are much easier run on and off, as well as laced, in case of necessity.

Fig. 54 shows an exterior view of the works of the Western Brick and Tile Co. This company was organized for the purpose of manufacturing front bricks for the Chicago market, with the Wm. L. Gregg machines, and have their headquarters at No. 53 Dearborn St., Chicago, Ill.

The machine shown in Figs. 55 to 59 has some peculi-

FIG. 55



arities in the arrangement of the mould-wheel, and in the manner of filling the mould and applying the pressure which is given to the brick by means of a toggle-joint, and we

illustrate it in detail. Fig. 55 is a perspective view of this invention. Fig. 56 is a side elevation. Fig. 57 is a plan view. Fig. 58 is a front view of Fig. 56. Fig 59 is a

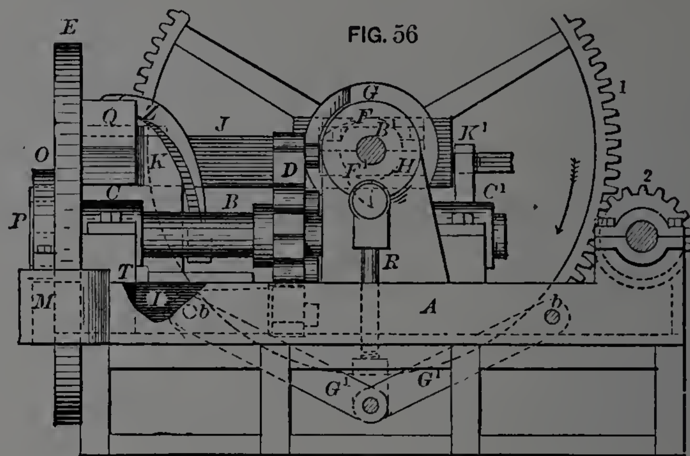


FIG. 56

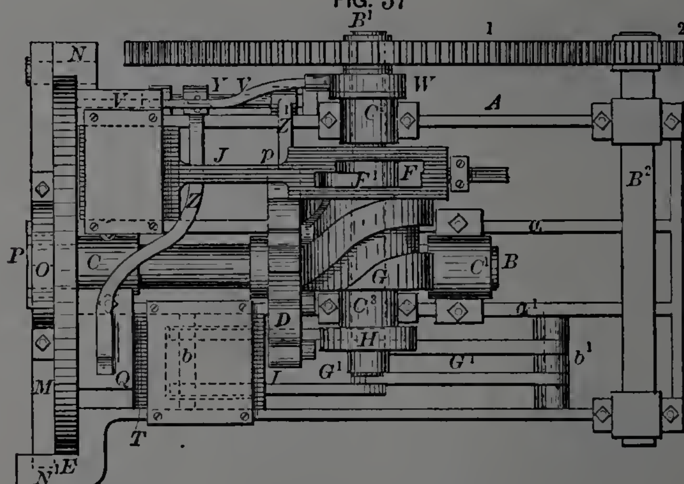


FIG. 57

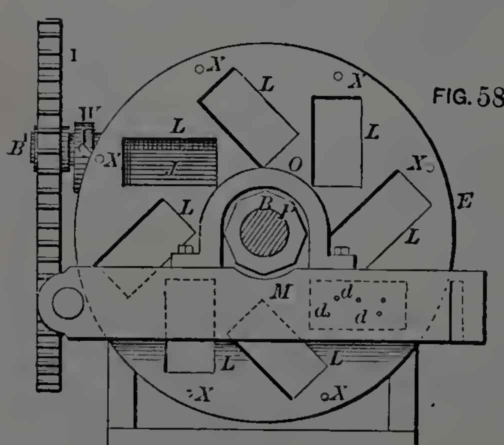


FIG. 58

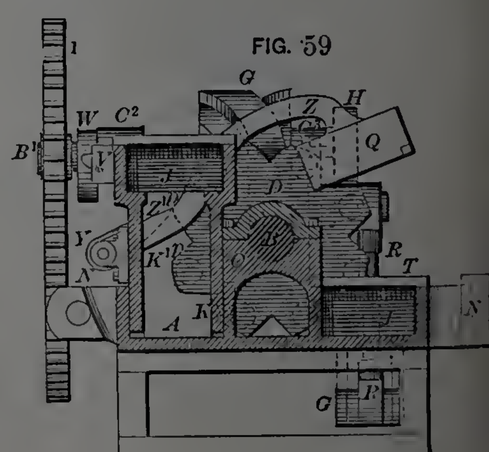


FIG. 59

front view of the machine with the mould-wheel and platen removed.

This invention relates to that class of brick-machines in which the clay, taken directly from the bank, and after being disintegrated and dampened, is compressed by a plunger into a mould, from which it is discharged after receiving pressure.

The object of this contrivance, which is the joint invention of Messrs. Geo. S. Selden and John N. McLean, of Philadelphia, Pa., is to provide a machine of a cheap and simple construction, combining maximum of strength and durability, and of an easy and rapid operation.

It consists of a mould-wheel perforated with rectangular openings, which form the brick-moulds, arranged in a vertical position at the front end of the machine, and having an intermittingly rotary movement imparted to said mould-wheel.

Two plungers for compressing the clay into the moulds, and discharging the moulded bricks, are operated in conjunction with the wheel, and receive motion from a toggle-joint, crank and cams arranged on a transverse shaft at the upper part of the machine. This shaft also carries a grooved cam-wheel, which works in connection with a pin-wheel on the mould-wheel shaft, and produces an intermittent rotary movement of the wheel.

The mould-wheel, as stated, revolves in a vertical plane, the moulds being brought successively up to the clay-box on one side of the machine and charged, the motion of the wheel ceasing while pressure is being applied; after which the moulded brick is carried by the further movement of the

wheel up to the discharging point on the opposite side of the machine.

The operation of moulding and expelling the bricks is continuous. While one brick is being pressed into the mould on one side of the wheel, the plunger on the opposite side is at the same instant forcing out a finished brick, which bricks may be received on an endless belt or wires, whichever is found most convenient.

A movable platen, to receive the pressure of the moulded brick, is placed across the front end of the machine, and is furnished with small openings for the discharge of superfluous clay.

A is a rectangular frame, with interior ribs *a* and a^1 of the same height, and extending the full length of the sides, and is mounted upon feet or other suitable supports; or the sides, with the supports, may form one piece.

B, Figs. 56 and 57, is a longitudinal shaft, supported upon bearings *C* and C^1, and carrying a pin-wheel *D*, and a mould-wheel *E* on its front end. B^1 is a transverse shaft, elevated above the shaft *B*, and supported in bearings C^2 and C^3, and carrying two cams, *F* and F^1, for operating the expelling-plunger, a cam-wheel *G* for operating the mould-wheel, and a crank-disk *H* for operating the compression-plunger.

The plunger *I* (shown in Figs. 56, 57, and 59), which compresses the brick, is placed within the clay-box *T*, and is operated by means of a toggle G^1, the front or reciprocating end of which is pivoted to the plunger at the point *b*, and the rear end, which bears the thrust, similarly attached on a

stationary pin b^1, with the centre-point pivoted to the lower end of the connecting-rod R, which connects with the crank-pin of the disk H.

The plunger J, which is moved to and fro by the cams F F^1 to expel the finished bricks, is located on the opposite side of the machine, a certain distance above the compression-plunger I, and is supported in guides K and K^1 secured to or forming a part of the framing.

The rectangular openings L L L, etc. (shown in Fig. 58), made in the wheel E, to form the brick-moulds, are arranged so as to alternately assume a horizontal position above and below the centre of the wheel, and directly opposite to the plungers. By this means the bricks are moulded and discharged on different planes, rendering the operation of charging the clay-box much easier, owing to its being within easy reach for shovelling in the clay, and discharging the finished bricks at the most convenient height for bearing them off.

M is a platen, arranged across the front of the mould-wheel, and pivoted at one end to a projection N, on the frame A, with the opposite end resting in a socket, and bearing against a shoulder in the projection N^1.

O is a yoke attached to the platen, and passing over an eight-sided or angular nut P, which is secured on the end of the shaft B. Each angle or corner of the nut bears against the upper part of the yoke as the wheel revolves and raises the platen to its proper horizontal position, and retains it in that spot while the wheel is at rest. When the wheel is again set in motion the corners of the nut are carried around,

which relieves and permits the platen to drop a short distance with the wheel, and cut off or break the cohesion of the clay. This platen may be made stationary, if found preferable.

All superflous clay in the moulds is discharged through openings *d d d*, etc., in the platen. These perforations are made tapering from the outside to insure a free outlet for the clay.

The wheel *E* is locked in position, when the moulds are opposite the plungers *I* and *J*, by means of a sliding bolt *V*, arranged on the left side of the machine, as shown in Figs. 57, 58, 59, and openings *X X X*, etc., Fig. 58, being made in the face of the wheel, on a line with the centre of each mould, to receive the end of said bolt.

W is an eccentric on the shaft B^1, to operate the bolt, and is adjusted so as to project the end of the bolt a slight distance in advance of the expelling-plunger, and to withdraw the same before the plunger is entirely clear of the mould.

Q is a hammer, placed directly over the clay box *T*, and is connected to a shaft *Y*, Figs. 56, 57, and 59, by means of a long lever, *Z*. The shaft is provided with a short arm Z,^{1} which rests upon projections *p p p*, etc., on the periphery of the pin-wheel *D*.

The motion of the pin-wheel raises the arm Z^1, and produces a partial rotation of the shaft *Y*, causing the hammer *Q* to rise and fall at intervals directly over the clay in the box, the object of which is to strike or pound the clay sufficiently to drive out the air and solidify the clay to a certain extent before it is operated upon by the plunger.

The plunger I and toggle G^1 can be arranged to produce a double pressure upon the brick in the mould. The crank is now so arranged as to apply the extreme pressure when the toggle is up to a perfectly horizontal line. If the throw of the crank is slightly lengthened, the toggle will be drawn up a short distance above a horizontal line, and the extreme pressure for an instant released, and will be again applied as the crank descends, and the toggle again assumes a horizontal position before its final descent.

Motion is communicated to the shaft B^1 by means of the spur-wheel 1, which receives motion from a pinion 2, mounted on a transverse shaft, B^2, at the rear end of the machine.

The wheel E is only required to move a short distance to bring the moulds successively opposite to the plungers, and for this purpose the elevation or curved portion of the groove in the wheel G is only required to extend a short distance on the circumference. The remaining portion of the groove extends in a perfectly straight line around the remainder of the periphery, by which means each pin on the wheel D remains stationary within the groove, while the mould-wheel is required to be at rest. At the proper time the curved portion of the groove is brought in contact with the pin, and a partial rotary movement is imparted to the wheel D, and also to the mould-wheel.

The clay is thrown into the box T through a hopper or otherwise, and after receiving a blow from the hammer Q, is forced by the moving plunger I into the mould in the wheel E, and after receiving pressure is carried by the revo-

lution of the wheel up to the expelling plunger *J*, where the brick is discharged.

The machine shown in Fig. 60 is the invention of Mr. Isaac Gregg, Jr., and it is known as the "Combination." This machine makes but one brick at a time, and will average about 10,000 per day of ten hours. The cost is $2000, and 15 horse power is required to run the machine together with the disintegrating mill.

Fig. 61 shows a machine manufactured by W. E. Tallcot & Co., Croton Landing, N. Y., for making a number of bricks in one mould, from tempered clay. This manner of moulding bricks is very common in all the States of New England, as well as in many of the Western States, and it is the usual method of producing all the common bricks made for the New York market. The principal points from which that market is supplied are Haverstraw and Croton Landing on the Hudson River, and several places along the Sound.

This method of moulding is much better adapted to light sandy clays than it is to those of a sticky nature, the great difficulty being to get the latter class of clays to slip easily from the moulds.

For working the class of clays which abound in the localities named this machine is most excellent, and it is one of the strongest and most improved of its kind, and the bricks made by this class of machines from loamy or light sandy clays are stronger after being burned than when made by hand. The principle of applying the pressure is by a cam, which operates the mould-driver and communicates a powerful and positive motion.

"Fire Clays of Missouri"
in
"St Louis Daily Globe-Democrat"
Sunday 1/8/88
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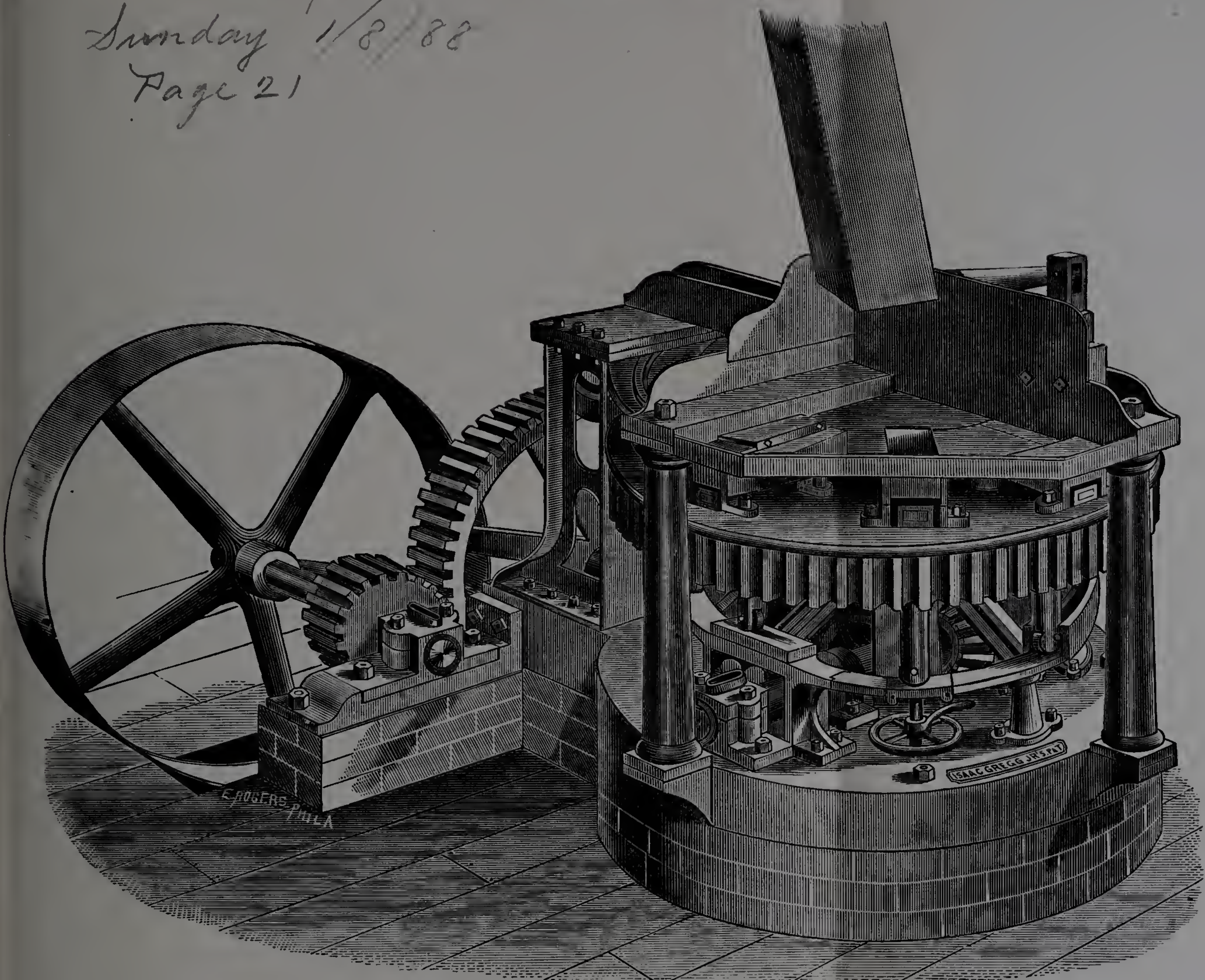


FIG. 60. COMBINATION BRICK MACHINE.—Page 188.

Fig. 61. Tallcot & C

Brick Machine.—Page 188.

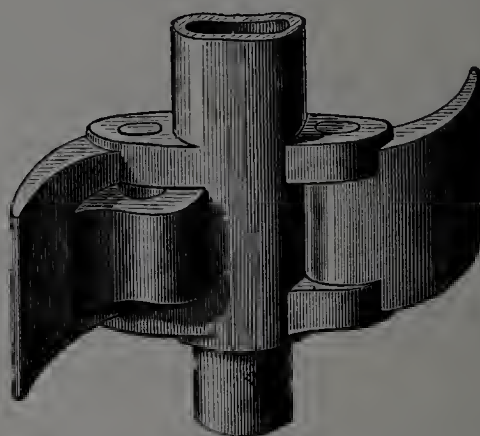
The machine is built to withstand the hard usage to which this class of machinery is subjected, the entire construction is of iron, the shafts are large, and good bearings are provided for them in long boxes. The base is good and has broad feet; the ample size and height of the tempering cylinder *A* gives the machine a good capacity for tempering; on the top of the cylinder is strongly bolted a heavy frame, thereby affording a steady bearing for the tempering shaft *B*, and also carrying the pinion shaft *E*, insuring permanent alignment of the driving gears.

There is a safety appliance in front of the clod-cutter, which is a gate or mouthpiece pivoted at each end; this mouthpiece is held in position by a vertical spring which engages the end of the arm *L*. Should a stone or other obstacle come in contact with the mouthpiece during the movement of the mould, the arm *L* would slip by the spring, allowing the mouthpiece to swing on the pivots, thereby allowing the obstacle to pass out, and no damage having occurred to the machine or mould, nor interruption to the working. The mouthpiece can be replaced by bearing down on the handle attached to the arm *L*, and should any obstacle present itself and be too large to pass through the mouthpiece, then the end of the cast-iron breaking-rod, which connects with the hooked arm *K* at the bottom of the machine breaks off, stopping the movement of the mould, when the large obstruction may be removed, after which the breaking-rod is again moved forward, connecting the end with the hooked arm.

Fig. 62 indicates the manner of securing the wiper or

"pusher" to the shaft, each of the two parts independent of the other, by means of pins which pass through projecting ears and also through the hub of each wiper. By this arrangement one or both wipers may, in case of breakage or

Fig. 62.



wear, be replaced through a large door in the back of the machine without removing the whole tempering shaft.

The weight of the machine is about 6700 pounds, but lighter machines are also produced by the same makers for horse-power and also for hand-power, the clay for the latter being tempered in some independent manner.

The power required to operate the steam-power machine shown in Fig. 61 is about fifteen horse, the product of the machine with that amount of power is about four thousand five hundred bricks per hour.

The prices of these machines, etc., on board the cars or boat at Croton Landing, N. Y., are as follows:—

Steam-power machine	$600 00
Horse " "	500 00
Hand machine using tempered clay	250 00
Mould, each	2 75
Trucks for wheeling bricks	13 00

Before considering the second class or expressing machines, which may be used for making either bricks, pipes, hollow flooring, and roofing tiles, terra-cotta lumber, etc., there is one point of importance that should be remarked upon, which is this: Bricks or hollow forms of earthenware that are expressed from the die of a machine and cut off by either wires or knives, are smooth and perfect in form provided the clay be not only free from lumps and plastic, but uniform and free from adventitious particles. If the clay contains stone or gravel that is not faithfully pulverized, and the senseless habit of mixing ashes or coal with the tempered clay is to be introduced, then the action made by the wires or knife will drag out more or less of these solid particles, and the ends will be very rough and the thickness sometimes uneven.

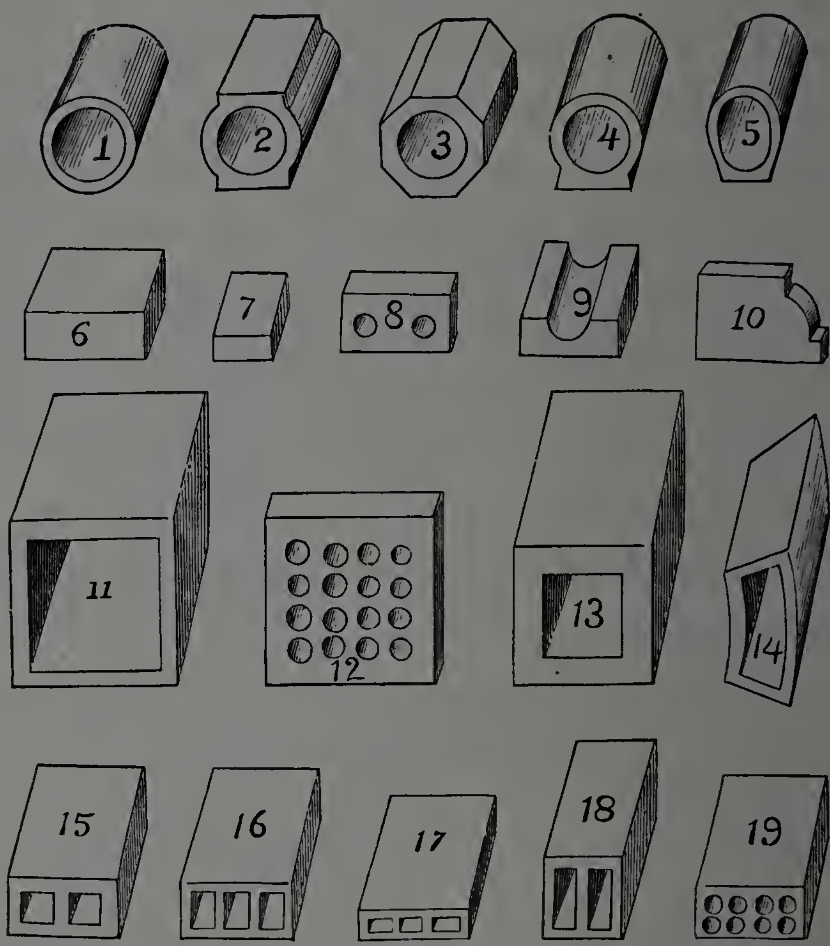
In Fig. 63, Nos. 1 to 19, are shown different forms of bricks, tiles, and other devices, which are made by some tempered-clay machines, the clay being expressed in the proper form, and then cut into any desired lengths upon a suitable arrangement of rollers.

For other forms of tiles see those in the hollow fireproof floors, shown in Figs. 120 and 121, Chapter VI.

Sometimes the clay pulverizers that will answer for preparing clay for damp or dry-clay machines will not disintegrate for tempered-clay machines. Clays of a very stony nature, too stony to be made into bricks with the stones in, or clays containing limestone in such quantities as to materially injure the bricks, require in such cases a different kind of clay mill to be employed, by which the stones are removed.

That is, all stones larger than a marble, the smaller ones being crushed to powder, and at the same time breaking up

Fig. 63.



1, Round drain Tile.
2, Flat Top and Bottom Tile, with Round Hole.
3, Octagon Tile, with Round Hole.
4, Flat Bottom Tile, with Round Hole.
5, Flat Bottom Tile, with Oval Hole.
6, Square Solid Building Block, $4\frac{1}{4}$ x $8\frac{3}{4}$ x $8\frac{3}{4}$.
7, Common Brick, $4\frac{1}{4}$ x $8\frac{3}{4}$ x $2\frac{1}{2}$, or other sizes.
8, Common Brick, with two perforations.
9, Pavement Gutter Brick.
10, Cornice Brick.
11, Chimney Liner.
12, Merill's Patent Paving Tile.
13, Hollow Building Block.
14, Well Stave.
15, Hollow Building Block, with two cavities.
16, Hollow Building Block, with three cavities.
17, Cellar Floor Tile.
18, Hollow Brick, with large perforations.
19, Hollow Brick, with small perforations.

the clay, crushing hard knots, and mixing the clay and sand together before entering the hopper of the machine.

This result is obtained in mild, weak, or loamy clays by passing them between conical rollers or other suitable devices, which crush the clay, separate the stones, and throw them out at one end of the rollers, through a spout.

These rollers are made of hard or chilled iron, running in adjustable boxes held in an iron frame, and geared so as to rub the clay as they crush it; thus, for ordinary mild clays, accomplishing all that is desired in this direction, and they are best cast in "shells" or "telescopes," so that the wearing parts can be renewed without replacing any of the other portions.

Some clays are so tenacious that they come from the bank in large lumps, and will not be disintegrated by clay-rolls of ordinary size and construction. Clays of this character are found particularly in New Jersey, parts of Pennsylvania and Illinois, the latter often being dredged from under water; the surface of the lumps being wet and slippery, rolls of the usual size will not grip them, so that ordinary conical rolls will not answer in such clays, unless the lumps are cut up; and to overcome this difficulty there have been devised what are termed by the manufacturers "Compound Clay-rolls," and which are shown in Fig. 64.

Fig. 64 shows a sectional side elevation of the compound clay rolls, and Fig. 65 shows a sectional end elevation.

These rolls consist of a pair of very heavy rolls of large diameter, carried on shafts of ample size, driven by heavy, coarse pitch gear, to which the large lumps of clay are fed,

Fig. 64.

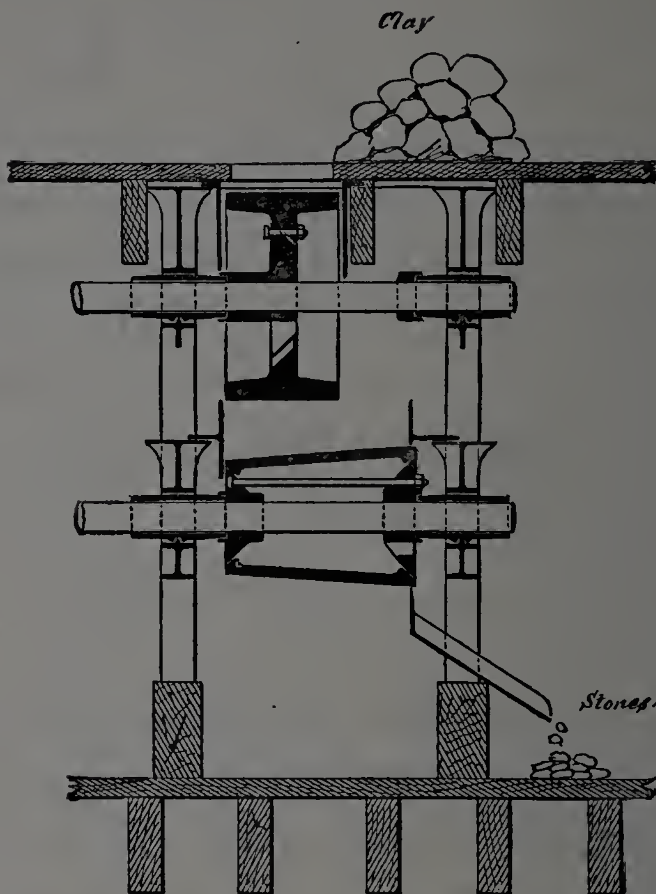
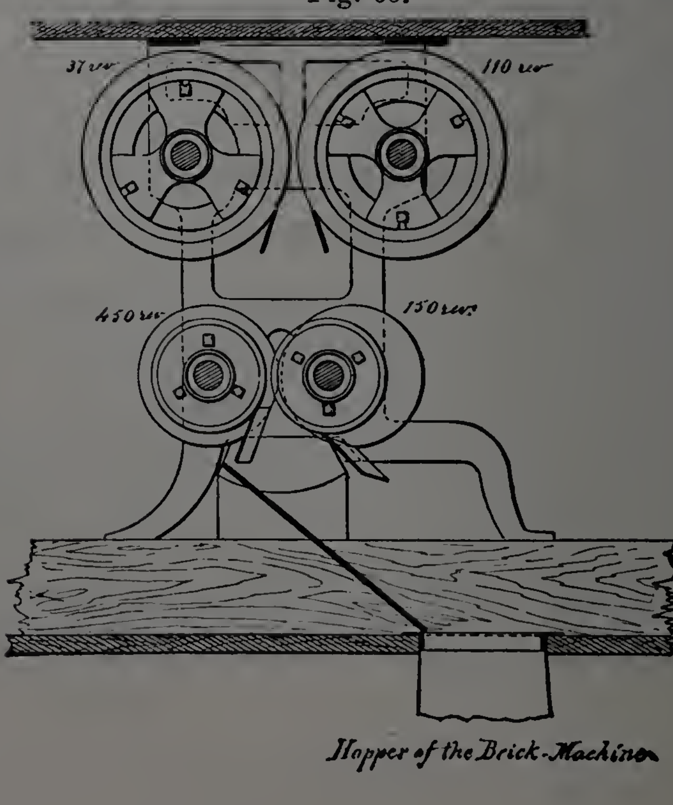

Clay
Stones.

Fig. 65.


37 rev.
110 rev.
450 rev.
150 rev.
Hopper of the Brick-Machine

stones and all. The rolls run at different speeds, and reduce the clay to lumps of, say two inches in diameter, rejecting very large stones, say all above four inches in diameter, and reducing the rest to two inches in diameter or less.

The crushed clay and smaller stones drop from these large rolls into the smaller conical ones, which complete the pulverizing of the clay, and eject the stones.

The weight of these compound rolls in place, with gearing and pulleys, framing all complete, is about 10,000 pounds, and the price as quoted by the manufacturers, Messrs. Chambers, Bro. & Co., Philadelphia, Pa., is nine hundred dollars including the right to run under the two patents, by which they are covered.

Fig. 66.

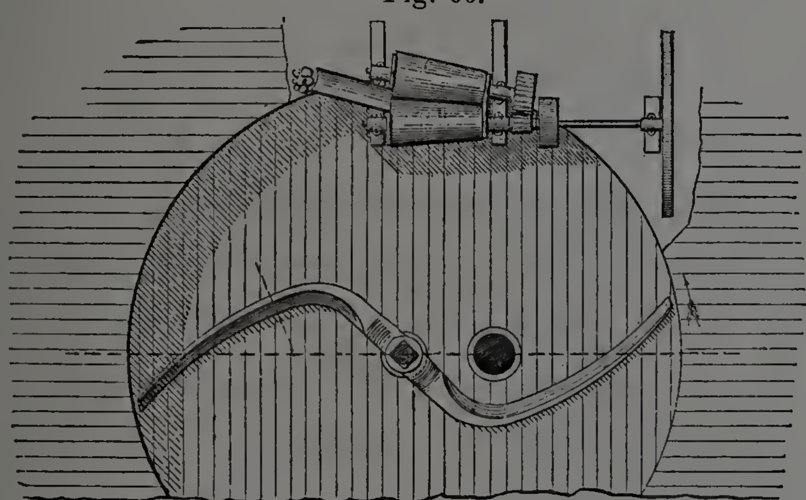


Fig. 66 shows a plan view of a machine for mixing hard and tough clay with sand and water. This mixer is placed under the clay rollers, and as the material falls into the pit in which the curved circular arms or sweeps revolve it is carried around, gradually mixed together, and worked towards the centre where it falls through the orifice in the

bottom of the pit and passes into the hopper of the machine, water falling upon the clay from a sprinkler overhead.

Frey's four roller crusher lately invented is a useful mill for breaking up rock fire-clay or hard brick-clay, or will receive the clay just as it is dug from the pit, and disintegrate it completely, and at the same time mix thoroughly any loam, sand, or other material that may be added to it. The clay passes directly on an endless belt or conveyer from the mill to the brick or tile-machine.

This crusher is made in different sizes for the various purposes for which it is adapted at the Eagle Machine Works, Bucyrus, Ohio.

This mill has also an attachment by which the clods are broken, before they enter the rollers, and by which also the stones are separated from the clay, which is a very desirable improvement in clay crushers.

The best method for elevating clay by machinery is eagerly sought after by brick manufacturers. The annoyance and loss caused by the breaking, in wet sticky clays, of rubber or leather "bucket belts," and the "hanging up" of open chain clay-elevators are often serious drawbacks and annoyances to those engaged in this line of production, and it has been proposed to employ an elevator, consisting of a plain rubber belt running over concaved rollers, at such angle of elevation as to carry up the clay without allowing it to roll off. The whole is so constructed as to receive the clay and carry it up, and discharge it into the hopper or rollers without wastage, loss of power, excessive wear, and without annoyance, and it can be arranged as deemed best, according to the lay of the clay-bank and yard.

By the arrangement shown in Fig. 67 no gangway is required, and horses are not compelled to haul the clay up

Fig. 67.

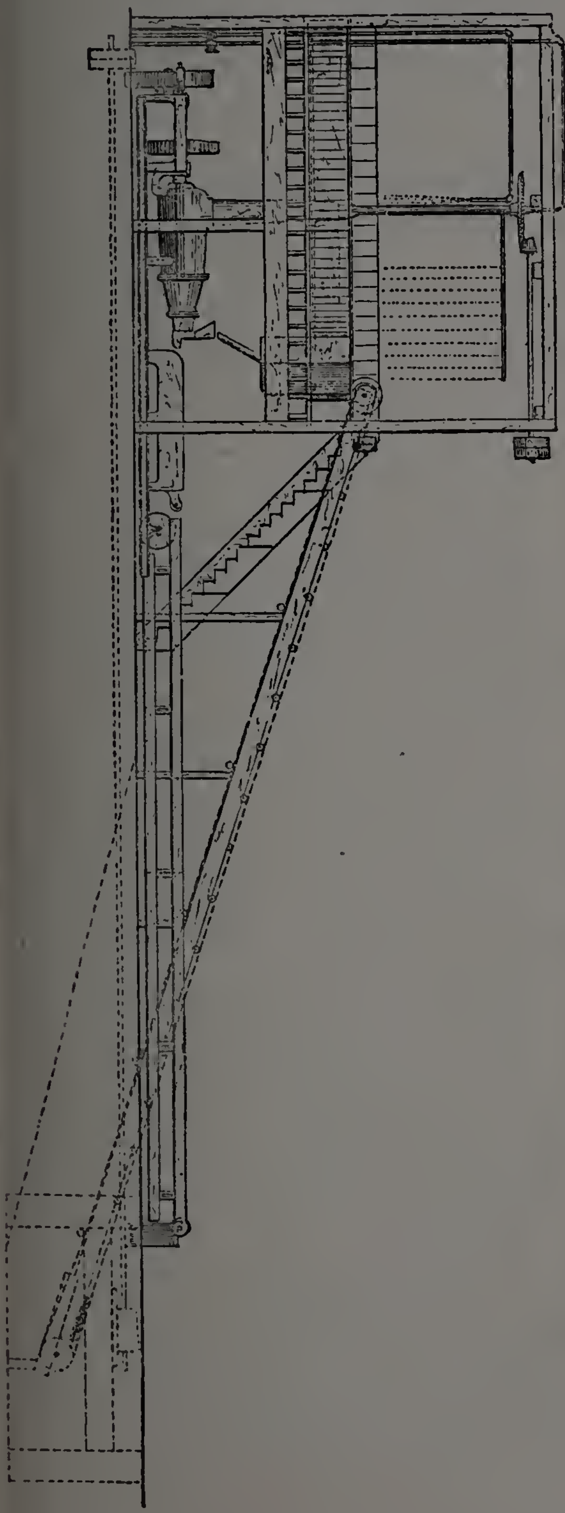
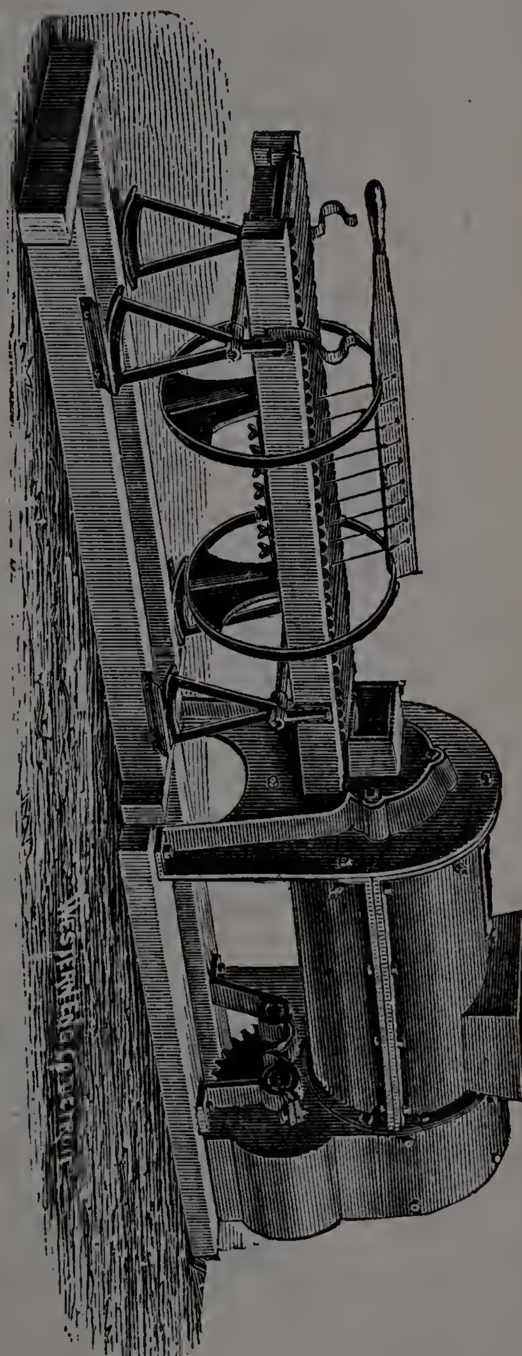


Fig. 68.

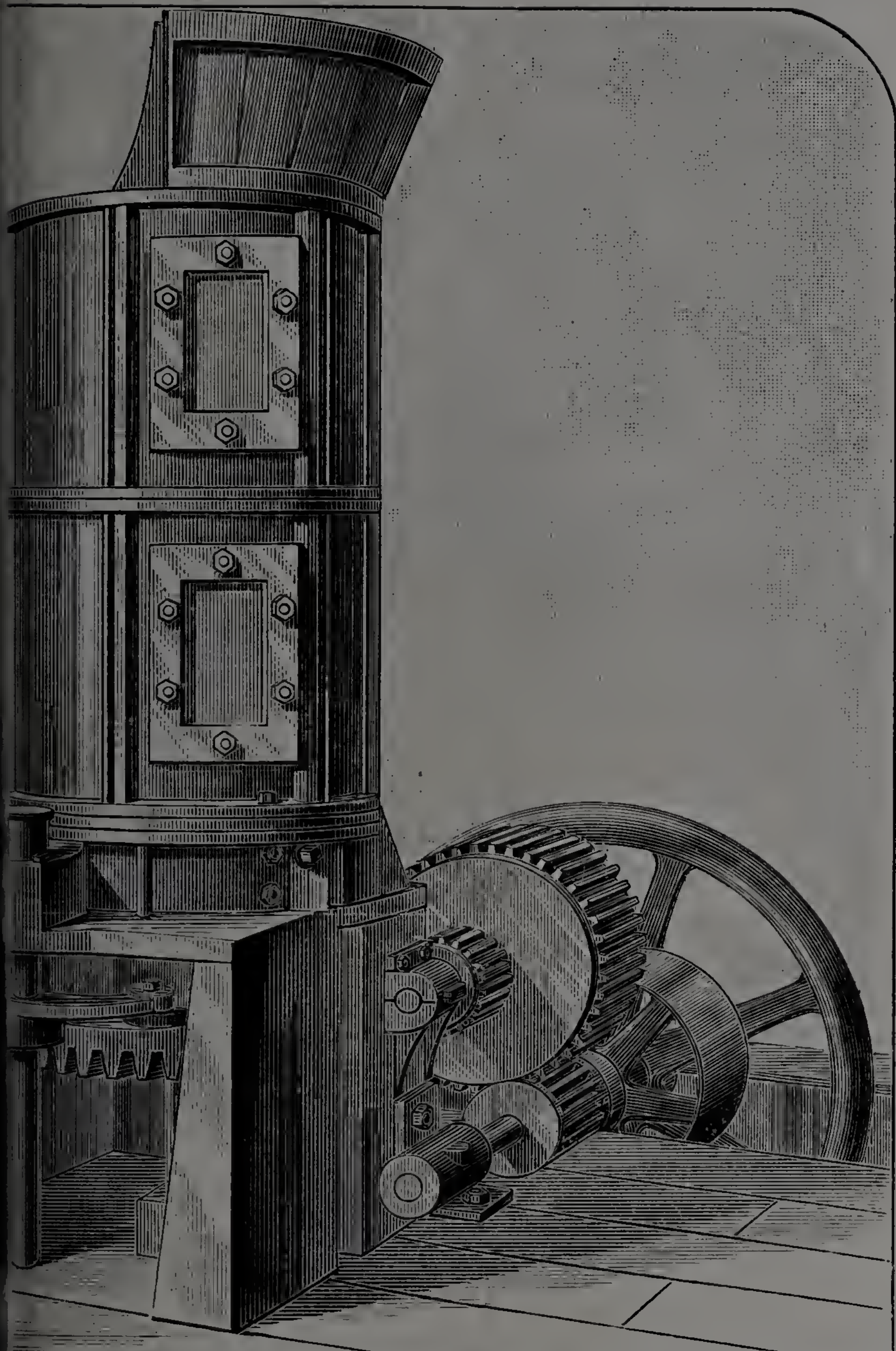


an incline to get over the machine, hence they can take more at a load, or it makes their work much less. All wastage, such as defective brick (from stones where rollers are not used), or improperly tempered or moistened clay that should be worked over, is carried at once back into the machine without labor; and where clays are to be particularly well mixed for pressed or other special bricks, the clay can be run over and over without any handling—the off-bearing belt delivering the bricks that are to be worked over, or all those not off-borne by the boys, direct to the elevator belt.

It is true that it is not always desirable to place the elevator as it is represented, and especially so where the bricks are off-borne two or three hundred feet by machinery, as in that case there is not much to be gained by this particular location of the elevator relative to the off-bearing frames.

The Centennial Tiffany Combined Brick and Tile Machine, shown in Fig. 68, was first exhibited at the Exposition of 1876, at Philadelphia, where a medal was awarded to the inventor, and this suggested its name. The inventor, Mr. Geo. S. Tiffany, resided at that time at London, Ontario; but in 1878, Frey, Sheckler, & Hoover, of Bucyrus, O., secured the right to manufacture the machine for the United States, and have, through the merits of the machine and business enterprise, increased the sales to an unexpected extent. The adaptability of this invention to the various branches in the clay business brought it in use for purposes which the inventor probably never contemplated while constructing it. The machine weighs 3500 pounds, made

FIG. 69. THE PEERLESS



K MACHINE.—Page 199.

entirely of iron and steel, and requires about 10-horse power to run it on brick, and from 15 to 20-horse power for tile. When used for a potter's mill a steel screen is used, screening the clay thoroughly with a small expenditure of power.

The capacity for tile of course varies with the size; the machine will make 15,000 small tile per day of ten hours; larger tile in proportion. For manufacturing hollow bricks, building blocks, and hollow fireproof flooring, it is a good and most efficient machine. It will make 12,000 bricks per day of ten hours, and the price of the machine with brick cutting-table and die complete for common bricks, is $450.

For contractors who are often obliged to manufacture, to supply their own wants, and persons who rent clay lands for the purpose of manufacturing, and do not wish to make permanent improvements on the land, which will be a loss to them when they remove, this machine is specially desirable. Expensive grading may be avoided, as the bricks are put directly in the hack. Good wheeling ground is all that is required for a yard. When water and good clay are convenient the work of manufacturing may commence in a few hours after getting the machine and a 10-horse power engine on the ground, and temporary kilns constructed of the dried green bricks.

The machine shown in Fig. 69 is known as the "Peerless" brick-machine, and two of them are in constant operation at the works of the manufacturers, the Peerless Brick Company, Philadelphia, Pa., where the machines have been run successfully both summer and winter during the past

five years. This company makes all of their common and pressed bricks upon these machines, but not their famous ornamental bricks, two pages of the designs of which are shown in this volume at pages 93 and 94, which bricks are moulded and finished by hand.

The machine shown above occupies a space of about 6 x 12 feet, and the height from foundation is about 8 feet and 6 inches, and it is solidly built, weighing about 6 tons.

This machine thoroughly tempers the clay, and its products are solidly and regularly formed, and much preferable to hand-made bricks. They easily withstand the ordeal of the drying oven, which is a valuable consideration to manufacturers, as they can by this means make the operations continuous throughout all seasons.

The bricks made by this machine stand well the process of burning, and there is not that cracking and bursting which is often to be observed in bricks that are less compactly made.

The capacity of the machine is about 25,000 bricks per day, and about 20-horse power is required to run it.

The price of this machine is $2000 on board at Philadelphia, and, in addition, $1000 is charged for the right to use it.

The machine shown in Fig. 70 is known as the "Chambers" tempered-clay brick-machine, and the size shown is guaranteed to make from 40,000 to 50,000 bricks per day of ten hours, and the price is $2500; in addition to which $1000 is charged for the right to use it.

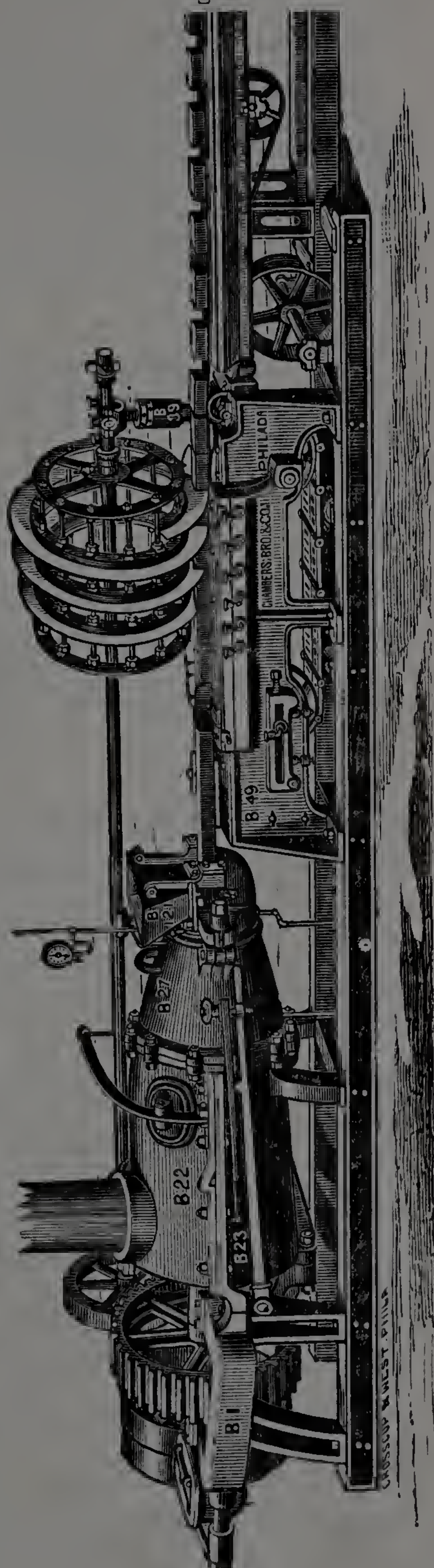
This machine is constructed almost wholly of iron and

steel, and is made very strong and durable, and it will be best understood by an explanation of each distinctive feature, and its operation as the clay advances through the machine. The operations of the different features are continuous one with the other, and entirely automatic.

Ordinarily the clay is taken directly from the bank and dumped on the platform covering the machine, and at the side of a conical hopper that leads into the tempering case of the machine, and mixed, when necessary, with loam or sand, and the requisite amount of water being added, to temper the clay to the proper consistency, the mass is shovelled into the hopper, and falls into the machine.

The hopper of the brick-machine proper is circular, to prevent the clay from sticking in the corners, and is larger at the bottom than at the top, as shown in Fig. 72, to prevent jamming of the mass. It enters the tempering case at one side of its cen-

Fig. 70.

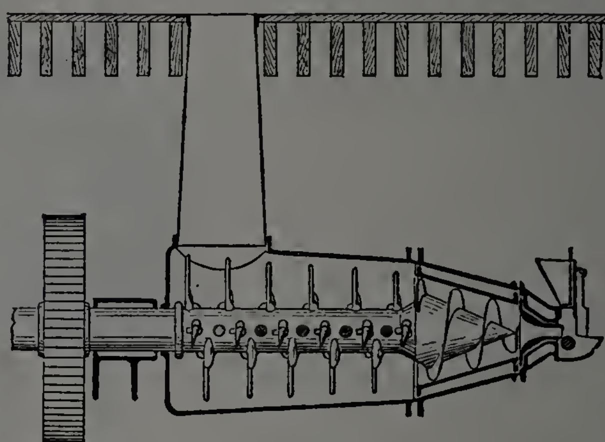


tre line, so that the clay in falling meets the revolving tempering knives as they are coming up.

This keeps up an agitation of the clay in the hopper, and tends to prevent clogging, and an irregular supply of clay to the tempering device.

The tempering portion of the machine (Fig. 71) consists

Fig. 71.

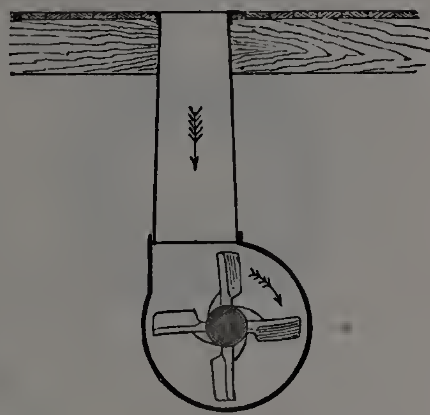


of a strong cast-iron conical case, in which revolves a horizontal shaft into which are set, spirally, strong tempering knives, or blades of wrought iron or steel, so that, as they pass through the clay, they move it forward. The clay being stiff, and not having much water on it, is not liable to slip before the knives, but is cut, and thoroughly tempered, the air escaping back through the untempered clay, so that by the time the clay reaches the small end of the tempering case, it is ready to be formed into bricks.

On the end of the tempering shaft (see Fig. 71) is secured a conical screw of hard iron, which revolves in a chilled-iron conical case, the inside of which is ribbed or fluted, lengthwise, so as to prevent the clay from revolving in it, and is chilled, to prevent wearing.

The screw being smooth and very hard, the clay slides on the screw, thus becoming, as it were, a nut; the screw revolving and not being allowed to move backward, the clay must go forward, sliding within the screw case. This case is heated by steam, which facilitates the sliding of the clay, and saves considerable power.

Fig. 72.



This operation further tempers the clay, and delivers it, in a solid round column, to the forming die.

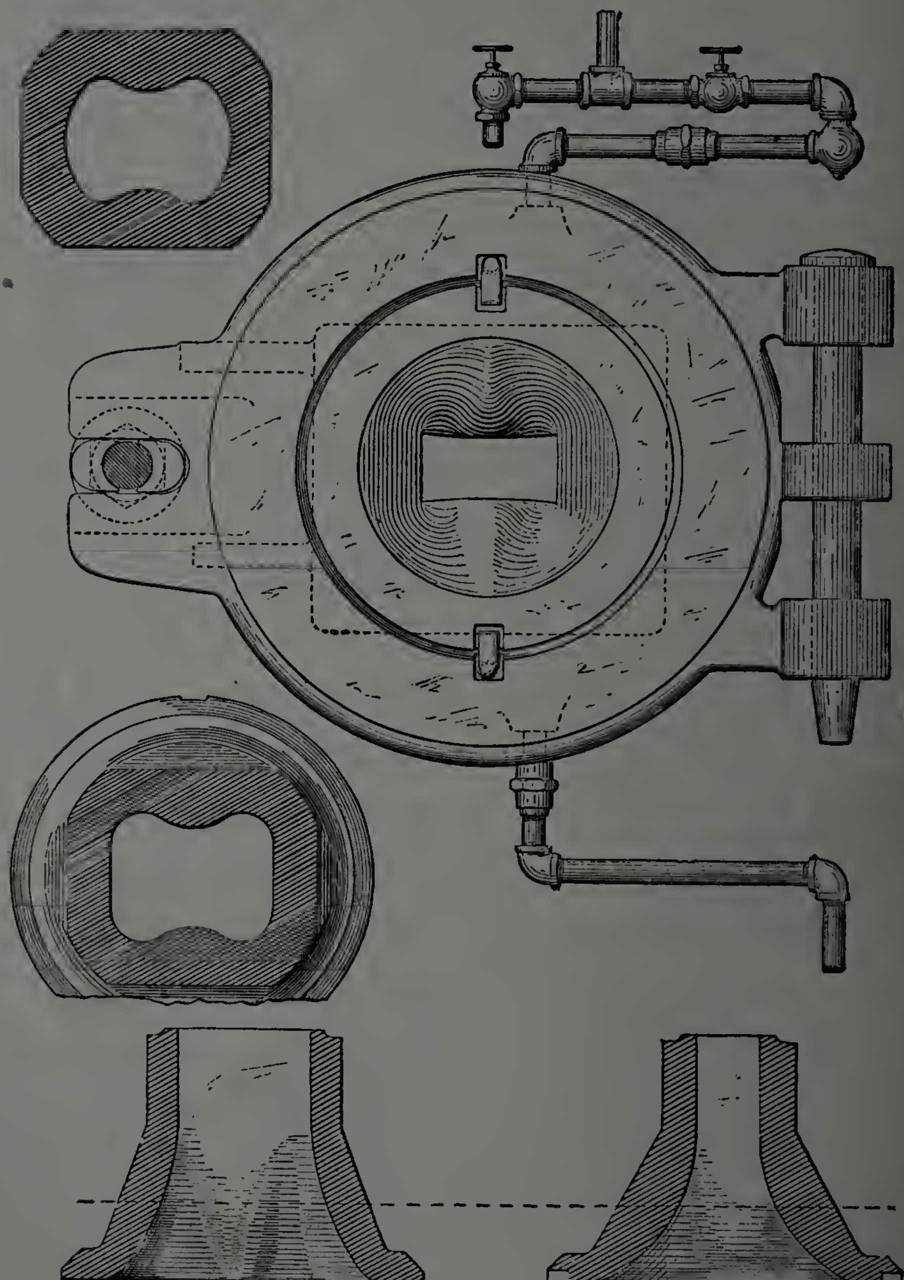
Fig. 73 represents the forming die held within the steam-heated former case.

Plastic materials, moving under pressure, follow the laws of fluids, and the great difficulty heretofore experienced in machines expressing plastic materials has been to make the flowing mass move with uniform velocity through all its parts. As the channel of a river flows faster than the shallow portions, or those near the banks, so does clay move through a die, the friction of the corners holding them back, while the centre moves more freely. Mr. Chambers overcomes this difficulty by the peculiar structure of the "former," which is so shaped as to facilitate the flow of the clay to the corners, and retard it opposite to the straight sides of the die, the projections being much larger opposite the larger diameter of the die.

For very wide and thin bricks the resisting projection is omitted wholly at the short diameter of the die, or at the

edge of the bricks, but the spreading of the clay outward to the edge is facilitated rather than into the corners only.

Fig. 73.



By this means the angles of the bar of clay are reinforced and made very solid and sharp, thus insuring perfectly square and well-defined corners to the bricks.

The "former" is secured to the screw-case by a hinge and swingbolt, so that it may be quickly swung open for the removal of stones. This swinging bolt is secured to the case by a pin of just sufficient strength to hold under normal conditions, and when undue strain comes from hard clay, etc., it yields, thus forming a safeguard against accidents arising from improper feeding. This "former" is also heated by steam, to facilitate the sliding of the clay.

The forming and finishing part of the die (which determines the exact breadth and thickness of the bar of clay or the brick) is a hard iron lining, that can be removed and renewed in a few minutes and at trifling cost, thus enabling manufacturers always to keep the dies (or moulds), and consequently the bricks, of standard size.

As the bar of clay issues from the forming die, it passes through a small chamber filled with fine, dry sand, which adheres to the surface of the bricks. The surplus sand is kept back in the chamber by swinging elastic scrapers, which allow the bar to escape with its adhering sand.

This sanded surface of the clay-bar renders the bricks, when green, much nicer to handle, prevents them from sticking together on the barrows or in the hacks, or on the drying cars, and improves them in color when burnt.

By its use a sanded surface is produced which closely resembles that of a hand-moulded brick, and renders them less liable to "daub" in laying. This sanding device performs the function of sanding a brick after it has been moulded, a thing never before successfully accomplished by machinery.

The cut-off of this machine, instead of the usual wires attached to a frame, consists of a thin blade of steel, secured to the periphery of a drum, in the form of a spiral, the distance between the blades of which is that required for the length of a brick, and the projection of which gradually increases from nothing at its first end to the full width of the widest brick to be cut.

This spiral knife runs perpendicularly, in openings, in the links of an endless chain, supported upon rollers, the chain being so formed as to support the bar of clay from the bottom and one edge; so that the clay is fully supported while being slowly cut off by the long drawing cut of the spiral blades, while passing through the openings in the chain.

The distance between the spiral blades being equal, the lengths of the brick are absolutely uniform, thus overcoming one of the greatest practical objections hitherto existing in the Chambers machine.

The drawing cut of the spiral blade cuts the ends of the bricks perfectly smooth, and almost mathematically square, thus correcting another defect hitherto existing in these machines.

The speed of this spiral cutting-blade is controlled by the movement of the clay itself; hence, no matter how irregular the flow of clay from the die, the spiral runs in exact unison therewith; consequently, there is absolute uniformity in the length of the bricks.

This manner of controlling the speed of the spiral by the clay is so positive that it will run at any celerity, from three to one hundred bricks per minute, while the machine runs at its regular movement.

The bricks, thus cut from the continuous bar, are separated and carried by an endless belt any desired distance; sometimes two hundred feet across the yard, from which the bricks may be wheeled to any point most convenient for "hacking," or loaded directly upon the dryer cars, as may be required.

All clay has more or less stones in it, and as it is impracticable to pick them all out, and requires considerable power and machinery to crush or screen them, there is a necessity of making some provision for them, even if there should be only one stone in every "ten thousand of clay."

In this machine the tempering-knives run six inches from the case, so that there is no danger of a stone five inches in its longest diameter catching between the end of the tempering-knives and the case, but they are frequently imbedded in the clay that occupies the space between the ends of the knives and the case. If a stone is more than three inches in diameter, and does not lodge in the stationary lining of clay in the case, it will lodge at the entrance to the expressing screw, preventing the clay from issuing at the die, when a safety-valve is forced open, through which the stone may readily be removed. If a stone less than three inches in diameter passes to that point, it will go through the screw, the openings between the threads being less at the entrance than at any other point; so that a stone that once fairly enters cannot lodge until it has reached the forming die, where it will lodge, if it is larger than the thickness of a brick, and prevent the proper flow of clay, causing the bar to split in two, or only part of the clay to

issue; this forming die being secured on hinges, in less than one minute it can be swung open and the stone knocked out, when the die is closed and the machine again started.

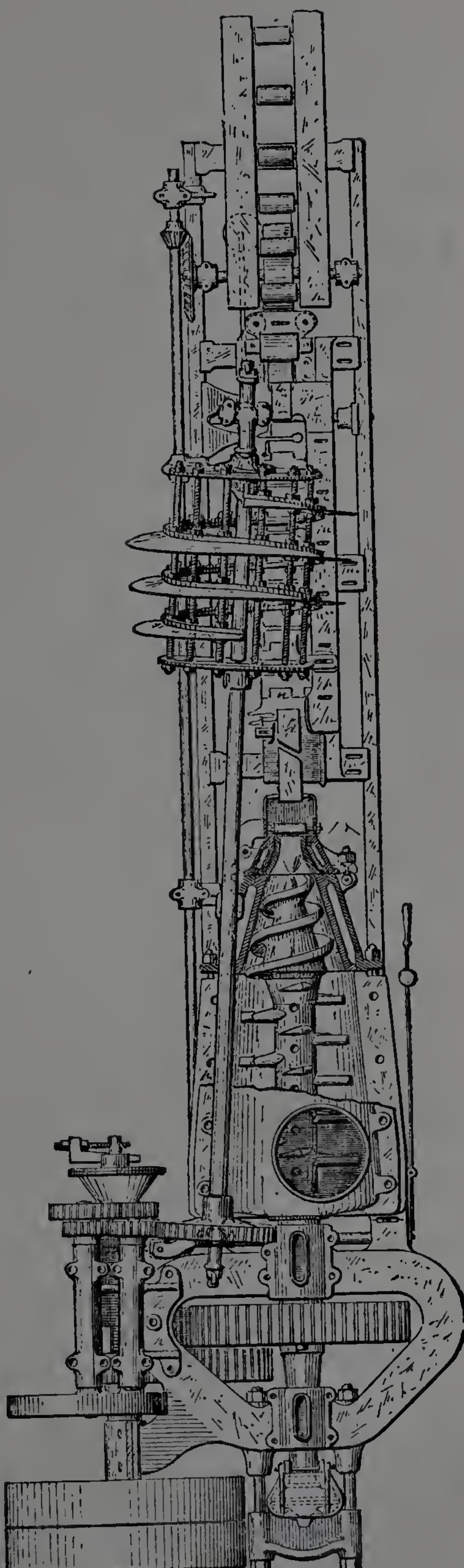
It is not very often that, in working good brick-clays, stones larger than the thickness of a brick get into the machine, and very seldom one larger than the opening to the screw; so that it is but seldom that the manufacturer is troubled with stones that will not pass the screw.

Small stones occur much more frequently, and pass freely through the machine, being buried in the bar of clay and passing to the cut-off. When a stone is buried in the bar of clay at the line of severance, the spiral knife must either cut through it, be broken, or some provision be made by which the blade will not be injured. The first is not practicable, as the stones are often very hard; and to break a knife every time it should happen to strike a stone would render the machine useless.

In order that the spiral knife should not be affected by stones, the shaft to which it is secured is held in position by gravity and counterweighted, so as to adjust it with just sufficient force to compel the knife to pass through the bar of clay. When the knife comes in contact with any hard foreign substance, as stones, brickbats, or bones, it rides up on the obstruction, and when passed falls, by gravity, to its original position, thus escaping injury, and not interrupting the continuous operation of the machine.

These spiral blades are made of steel, and will cut off, in good smooth clays, from two to five millions of bricks, and in stony clays from one to two millions. These blades are

Fig. 74.



secured to the drum by a spiral clamp, and can be replaced in a few moments.

Fig. 74 shows a plan view, partly in section, of the Chambers brick-machine.

After moulding, the next step in the production of machine-made bricks is the drying, and this can be accomplished by either natural or artificial means.

The natural means is to place the bricks in the sheds and dry them by the atmosphere.

In large daily productions of bricks it is found very difficult to dry the stock in sheds, which, being large and covering a great area of land, makes the cost of wheeling the bricks to and from them very great. In addition, the bricks, after being placed in the sheds, are liable not to dry, and as they can be set in the kiln in a damp condition only with a positive certainty of losing them, valuable time would be

lost and great annoyance caused. Altogether, the first cost for brick-driers, cars, and tracks, is more than for common drying sheds and barrows, but the saving in the cost of handling the bricks much more than compensates for this. The expense for fuel and attendance while the bricks are in the driers should not be charged wholly against them, as time and fuel are largely saved in the burning.

The great advantage in the employment of driers is that the work can be continued throughout all seasons of the year, especially in the early spring, when bricks are usually higher than at any other period of the year. The effective system of heating the driers by steam coils, alluded to in Chapter VII., can be applied if desired.

In all works producing bricks in large quantities by machinery, it is much cheaper in the end to place the bricks directly upon cars and carry them to suitably constructed driers erected for the purpose of expeditiously extracting a portion of the surplus moisture from the stock.

The drier, shown on page 214, is controlled by Messrs. Chambers Bro. & Co., of Philadelphia, Pa., and consists of six or more brick flues, about forty feet long, three-and-a-half feet wide at bottom and two feet at top, and four feet high, built of bricks, with a railroad track through each flue, slightly descending from the machine, with fire-grates and doors at lower end, and stack at the upper end of the drier.

Each flue has an iron door, sliding in iron grooves and counterpoised by a weight at either end, so that the flue is readily opened and closed for the admission and exit of the cars loaded with either the green or dried bricks.

From the grates, upon which coal, coke, or wood is burned, the results of combustion are conveyed along and near the bottom of the tunnel to near the stack end, and are allowed to escape gradually, through perforations or slots, up, under, through, or between the bricks on the iron cars.

In addition to the gases from combustion a large amount of air is admitted over the furnace into the flue, which becomes heated, and when distributed through the bricks by means of the adjustable flue, takes up the moisture from the bricks and carries it off through the stack.

The cars are constructed of iron, and are designed so that the slats can be turned up and over on the next one, and the "off-bearers" from the machine, and the "tossers" in the kiln can stand within the body of the car, close up to their work, for loading and unloading the bricks. This is an improvement of far more value than would at first appear, for by standing so conveniently to the work, both to the off-bearing frame of the machine and to the hacks on the car, one hacker or off-bearer is enabled to perform much more work than he would do if compelled to lean over the width of the car.

The boxes on these cars are made with friction-rollers in them, and run without lubrication.

They travel so lightly that a boy will transport four hundred and forty bricks on one of them with greater ease than a man will push a wheelbarrow load on the best-designed barrow.

At each end of the flues is a transfer or switching car, which transfers the loaded cars from a single track, running

from the machine, on to any one of the six tracks running into the flues; and in like manner from any one of the six flues to the track running to the kilns.

The loaded cars are transferred into any one of the kilns by means of transfer cars, and the empty ones returned to the machine by a return-track, outside of the flues.

The whole of this arrangement may be under an inclosed building, and quite comfortable to work in at all seasons.

The cars are moved to the side of the machine, where the bricks are hacked on them direct from the off-bearing apron, and require no more handling until ready to "toss" in the kiln. One man will hack from 20,000 to 25,000 bricks upon these cars, ready for drying, direct from the machine, in ten hours.

The loaded car is then run on to the transfer car, and from thence into any one of the flues, where a current of heated air (an artificial summer breeze) is forced through them, the steam from the bricks near the fire condensing on the surfaces of the cold ones, and preventing checking or cracking, while the bricks absorb the heat from the steam.

When the bricks directly over the fire are dry, the car is run out to the kiln to be set, a fresh car being put in at the upper end, pushing the others down, and bringing another partially dry car immediately over the fire, and so on.

One ton of anthracite coal will dry 25,000 bricks, but the dryer saves a large proportion of coal in the burning of the bricks (as we have before stated), and saves handling the stock twice—once in hacking or laying on the floors, and once in reloading on barrows to be wheeled to the kilns.

It also dispenses with two or three wheelers from the machine to the sheds, and one of the wheelers and one loader in the setting-gang, the cars running directly from the machine into the tunnel, thence into the kilns, the bricks being set from the cars, one of the setting-gang tossing and one managing the cars alternately. The cost of the coal to dry bricks artificially is much more than saved by the economy of labor, while the amount of fuel to burn the bricks is less, because the bricks are more thoroughly dried than by the open air. Hence the expense of artificial drying is less than that of sunshine.

The advantage of running an establishment in all weathers, and twelve months in the year, instead of eight, and having bricks in the spring, when they command the best price, is too evident to need argument, to say nothing of the advantage to be gained in giving employment to your workmen the whole year round, and the difference in the cost of labor between winter and summer; but all of these advanvantages sink into insignificance when the superior quality of the bricks is considered. The bricks not being disturbed from the time they are put on the cars until they are run into the kilns thus avoid two handlings in loading on the barrows for the two wheelings, whereby their shape and angles are preserved, rendering them much more perfect when burnt, and increasing their value in the market, while their cost is less than shed-dried bricks.

We do not feel that it detracts from the value of this dryer frankly to state that it will not work in all clays, as it is not usually practicable in very strong clays, or clays that will

not dry without cracking in the sun, but for loamy or sandy clays, or any that do not easily crack in drying, we can recommend it as economical and profitable; but still we would advise a practical test of the clay rather than to erect a dryer, subject to the uncertainty of the clay standing such treatment.

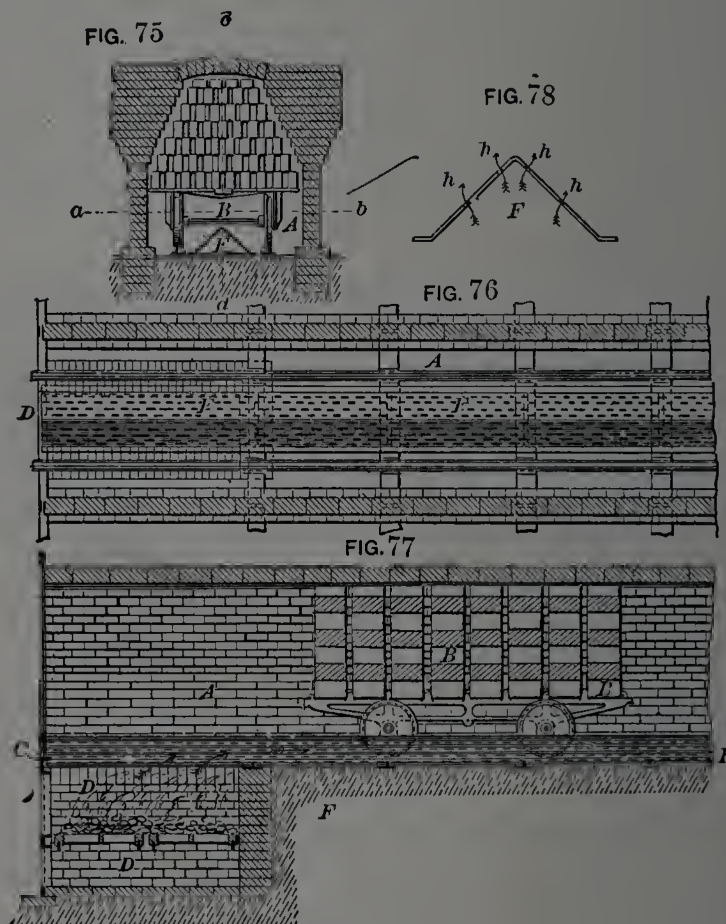


Fig. 75 is a transverse vertical section of a drying-flue provided with the improvement which has been mentioned for distributing the heat. Fig. 76 is a horizontal sectional view on the line *a b*, Fig. 75. Fig. 77 is a vertical longitudinal section on the line *c d*, Fig. 75. Fig. 78 is a cross-section, enlarged, of the air-distributing or diffusing flue.

This invention consists in the combination, with the main flue of a usual kiln for the artificial drying of green bricks or other moist articles, of an auxiliary flue, whereby the heated air from the furnace is caused to be diffused along the length of the main flue and directed up through the bricks.

The usual construction of the brick-drying kilns which this device is designed to improve consists of a large flue *A*, built of bricks, with a furnace *D*, at one end and a smoke-stack at the other, together with sliding iron doors for opening and closing the entrance and exit of the kiln, and provided with a track *C*, on which run the iron trucks *B*, which carry the hacked bricks to be dried. The laden trucks are pushed in at the stack end, and, when the bricks are sufficiently dried, out at the furnace end. The defect in such kilns arises from the tendency of the heated air to ascend directly from and near the furnace to the roof and upper part of the kiln, and to pass off into the stack without having done its full duty—that is to say, without having taken up all the moisture from the bricks which it is capable of absorbing—and thus, while the upper tiers of the bricks become rapidly dried, the lower tiers dry slowly and at a loss of time and an excessive cost of fuel.

This obvious and serious defect is obviated by introducing an air-diffusing flue *F*, having numerous perforations *h*, which flue is located at the bottom of the main flue, and preferably between the tracks *C*, directly beneath the middle of the trucks, and extending from over the furnace *D* the whole length, or nearly so, of the main flue, as shown. It

is preferable to make this auxiliary flue of sheet-iron, bent into the angular form shown in the drawings, its side edges resting upon the floor or upon the sleepers of the track. The body of heated air rising from the furnace D, instead of being entirely free to escape, as heretofore, to the upper part of the kiln, is diffused by the auxiliary flue F along the entire length of the drier, passing up through the perforations h, as indicated by the arrows in Fig. 78, and, coming into contact first with the lower tiers of bricks, ascends through the superposed tiers, and finally passes off through the stack charged with moisture. Thus the drying of the bricks is more rapidly, evenly, and economically effected than has been heretofore possible without this improvement.

Sometimes the cars themselves can be made the means of drying the bricks as well as of carrying them from the machine to the kiln.

This manner of drying can be performed either in the open air or sheds, or the cars can be placed in driers if so desired. This class of cars can be used for drying terra-cotta, drain-pipes, etc., as well as for bricks.

The drying-car, shown in Figs. 79, 80, and 81, which is the invention of Mr. Wm. L. Gregg, of Chicago, Ill., is to provide a convenient and efficient portable drier for bricks and other articles made from clay, as well as for various products of chemical and other manufacturing industries which require to be subjected to a process of desiccation, and subsequently transported from one portion of the plant or factory to another.

To this end the improvements consist in the combination, in a drying-car, of running-gear, a series of tubular supports

for the articles to be treated, and valves governing the admission and exit of steam or heated air to and from the tubular supports, and affording attachments for couplings, whereby the car may be connected to a steam boiler or other source of heat, and to another car when desired.

This invention provides a car which is simple, strong, and durable, and in its use a material economy of time, labor, and fuel is attained by applying the heating medium to any required number of the articles to be dried within the capacity of the car as soon as placed upon the racks, and completing the operation thereon (which may be effected, if desired, within a closed chamber or apartment having suitable apertures for the escape of the vapors), instead of, as has heretofore been the case, employing the heat of a kiln, in which a small quantity of the articles cannot be economically dried, nor can the degree of heat be conveniently or expeditiously governed and altered.

Fig. 79 is a plan or top view of a drying-car embodying the improvements; Fig. 80 a vertical longitudinal central section through the same; and Fig. 81 a vertical transverse section through the same as provided with additional drying-racks.

To carry out the invention, construct a rectangular rack or platform *A*, of gas or steam pipes, united at their ends by manifolds *a*, elbows or fittings a^1, or in any other suitable manner, the arrangement of the pipes and connections being such as to provide a circulation of steam or hot air from one end of the rack to the other through each pipe of the series. A valve or cock a^2, is fitted to each end of the rack, so as

to govern the admission and exit of steam or other heating medium to and from the interior of the same, each of the valves being threaded or otherwise adapted for the attachment of a flexible coupling or hose a^3, by which communication may be established with a steam-boiler or other heater, or with the rack of another drying-car.

Fig. 79

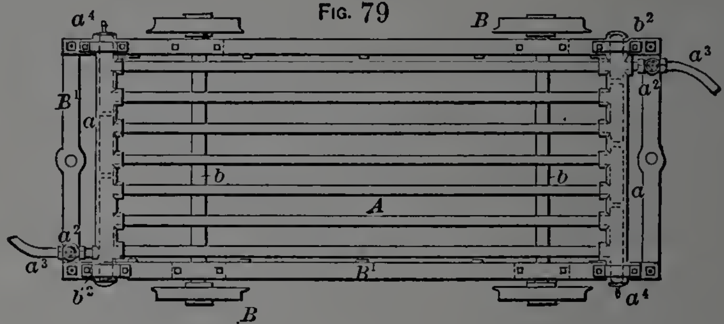


Fig. 81

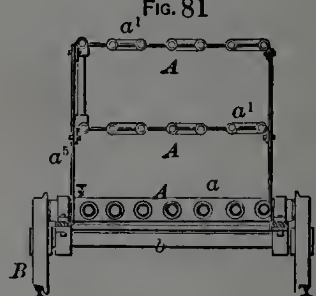
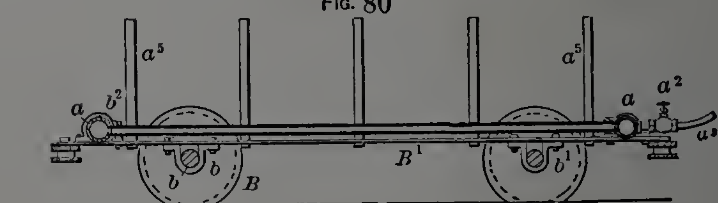


Fig. 80



Drip-cocks a^4, one or more, may be provided for relieving the rack from any water of condensation that may accumulate therein.

The form of rack shown in the drawings consists of a series of pipes arranged longitudinally, and connected by end manifolds a, having internal partitions, which provide

a continuous passage, in alternate directions, through all the pipes; but the arrangement and method of construction may be varied, according to the judgment of the constructor.

The tubular rack A is mounted upon running-gear, consisting of wheels B and axles b, the wheels being either fast or loose upon the axles, as preferred. In the instance shown the axles rotate in bearings b^1, secured to the lower side of a rectangular frame B^1, to the top of which the rack A is secured by straps b^2. Such arrangement of a separate frame supporting the drying-rack is deemed preferable for use in cases where two or more cars are to be coupled together and moved with their contents from place to place, as the pipe-joints are thereby relieved from longitudinal strain, and convenient means for attaching the axle-boxes and coupling the cars together are provided.

It will be obvious, however, that when desired for the purpose of reducing weight and cost of construction, the drying-rack may serve as the sole framing of the car, and the wheels can either be made to revolve on journals formed upon the end manifolds, or with or upon axles supported in bearings connected to the manifolds, or to the pipes themselves.

Vertical bars a^5 or slatted side pieces of any desired form may be secured to the car, to afford lateral support to the articles placed upon the rack.

In the transverse section, Fig. 81, the car is shown as provided with three separate tubular racks, arranged one above the other, which construction will be found desirable, where a large amount of heating-surface is required.

The pipes of the upper racks are connected at their ends by elbows or fittings a^1, and are supported by transverse straps secured to the vertical bars a^5.

After the bricks have been properly dried, the next step is to place them in the kiln to be burned.

The setting of the machine-made bricks is usually done by the day; there should be no wheeling, as is the case with hand-made bricks.

One laborer to push in all the cars for one gang, and three men in the kiln, are the usual complement of one machine-setting gang.

Two of the three men in the kiln should be setters, as one of them can be working in the "bottom" or building the arches, while one is tossing, and the other setting the bricks on the lower bench. When it is desired to put on the top bench, one man can toss, one stand between the tosser and setter, and one set the bricks.

In very large works it is not unusual to have four of these gangs in one kiln at the same time; twenty-five thousand bricks is the usual amount set by each gang. In some works, where all the machinery is in perfect running order, the proprietor requires a certain number of bricks to be made and handled for a day's work; and as soon as this is accomplished, be it in eight, nine, or ten hours, the men are at liberty. In one large brick-yard, producing bricks by the machine process, located in the city of Washington, D. C., the number of perfect bricks required to be made and set is eighty-eight thousand; as soon as this is accom-

plished, all hands in the works stop, including laborers in the clay banks, horses and carts, etc.

It is not often that the time exceeds nine hours.

The bricks made by this company are rubbed in moulding sand, the same as that used for hand-made bricks, and as the bricks are damp, the sand adheres well, and in the kiln the color of the stock, after burning, is uniform. The description which has been given in the preceding chapter, in regard to the burning of bricks, applies to machine-made bricks as well as to hand-made stock, with the important differences: that the firing at the first stages should be slower, and in the setting or finish the firings should be more frequent, and heavier.

Pressed or front bricks are produced by a combination of the hand-made and the machine processes. The finishing of this class is sometimes done in a press run by steam power, but the usual way is to mould the bricks by hand and make them slightly larger than the size of the press-box in which they are to be finished.

The moulding, drying, and pressing of front bricks are conducted entirely under shelter; the hand-press gang is composed of the three members, the moulder, who also does the pressing, the temperer, who also does the wheeling of the clay, and the off-bearer, who also rubs the finished bricks with very fine moulding sand.

A day's work for the press-gang is to temper the clay, mould, press, and finish one thousand one hundred and sixty-seven bricks. Pressed bricks are seldom hacked on edge in the sheds, but are laid flatwise, each pile being a

separate one, and a space of about three inches is left around each hack; they hold shape better in this manner of drying than if hacked on edge, and after they have been pressed they are hacked differently, as will be explained.

For the information of brick-makers in distant places, where pressed bricks have not been made, we elaborate further upon the general plan of making them by hand.

It is important that the clay should be well tempered, the clay-tempering-wheel producing the best. The bricks should be moulded free of flaws or sand-cracks, and the mould, when in use, should be kept well cleaned. Those in general use in Philadelphia are known as the "single cast-iron moulds." The moulding sand is an important item in making pressed bricks, as the color and smoothness of the brick depend on it. A sieve having about sixty meshes to the lineal inch is used for preparing the sand for moulding the bricks. The bricks are placed flat on the floor, and when pretty dry, a light sieving of sand is put over the faces. They are then turned over that they may dry more regularly. Sheds built expressly for the purpose are also used for pressed bricks. The roof is made to open so as to admit wind and sun when required. A good roof for this purpose is shown in Chapter IV., Figs. 14, 18, 20, 25, and 26. Where the bricks dry too fast, a piece of damp carpet can be laid over them and sprinkled occasionally with water. When the bricks are in a proper state for pressing—say, when they can be handled without finger-marks—the press is taken to the bricks. Placing the press on boards, the bricks are carefully put into the mould, great care being exercised that they are not marked in dropping

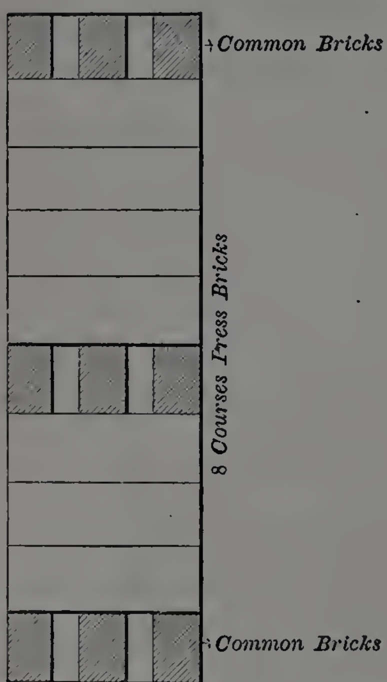
them in. There must be no finger-marks on them, and all "crumbs" must be wiped off the face of the mould; also, off the lid. After the bricks are pressed they are generally laid flat, five or six high, and when partly dry they are slightly rubbed with the hand and piled pigeon-hole shape, which allows further drying. In some cases they are piled in squares, edgewise, five or six high. When dry enough, they are placed on barrows, with strips of wood or soft blankets between each course, and taken to the shed to remain until required for burning. It is highly important that the mould lid and plate of the press shall be kept clean when in use. Occasionally raise the plunger plate, and wipe off any dirt that may have accumulated on it, and apply a slight oiling to all the parts. When the day's work of pressing is ended, make it a fixed rule that the presser shall take out the plunger, clean the mould lid and plate, oil the surfaces and replace. Occasionally, while working, the presser should clean the plunger and keep it always well oiled, as should be all the wearing parts of the press.

The pressed bricks are usually set eight courses high in the kilns, but we have seen them carried ten or twelve courses in height in the city of Philadelphia. The top course does not usually extend closer than the fourth course from the top. They are also set differently from the way in which common bricks are placed, the desire being to preserve the faces which are to be exposed in the wall of a building. There is not the same amount of crossing or "checkering" of this class of bricks as in common stock.

The bottom, one middle, and the top course are crossed

or checkered in setting eight high, and Fig. 82 will show the manner of placing them in the kiln. The bricks are set one directly over the other on edge; the "cross-ties" shown are to hold the body and keep the pressed bricks from "wabbling" or slanting from either side. Great care and experience in setting as well as in burning kilns containing quantities of pressed bricks are very essential. Too hard firing in settling the kiln is liable to cause all the pressed bricks to "tumble" or fall, and the fires at this stage are consequently lighter and more frequent than when the kiln contains only common bricks. The pressed bricks are also handled much more carefully than common bricks, being taken up one at a time, placed lightly on the barrows, and are carefully handled and tossed also one at a time to the setter. No extra money is paid to the setting-gangs for handling pressed bricks; the work is included in the task.

Fig. 82.



Elevation showing manner of setting pressed bricks in the kiln.

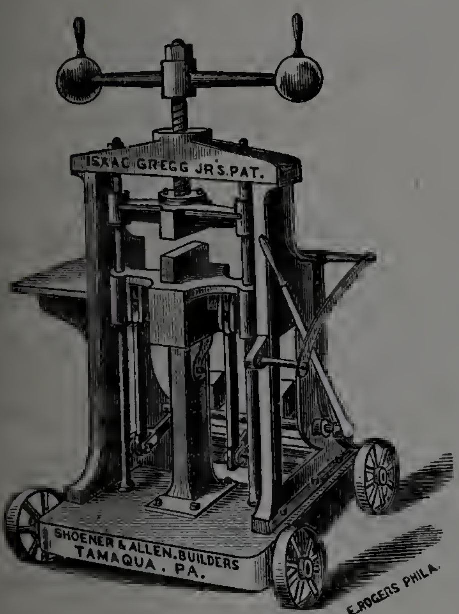
In all stages the "gluts" as well as the finished green pressed bricks should be protected from unequal drying; the sheds in which they are made should have movable slat sides, which are closed during periods of strong winds.

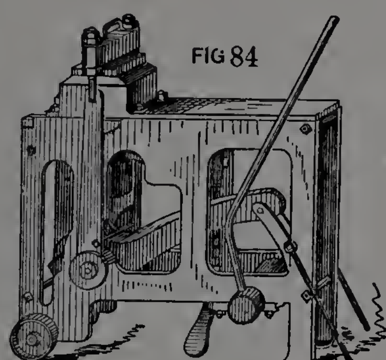
Ornamental bricks are usually made in the same manner as fine pressed bricks, the quantities produced for a day's work are less, but vary with the size and complications of

the designs. The hand-presses in which ornamental bricks are pressed sometimes have larger mould-boxes than for ordinary pressed bricks, and when small designs are to be pressed, which do not fill out the mould, suitable blocks of hard wood are used for "fillers" between the patterns.

The brick-press shown in Fig. 83 can be used for re-pressing edgewise all grades of front, shape, and ornamental

Fig. 83.



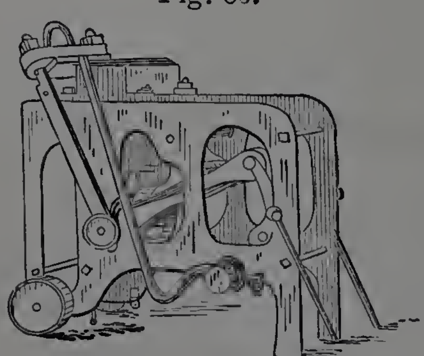


bricks, and also for fire-bricks. This press is made by Mr. Isaac Gregg, Chicago, Ill., and the price on board is $300.

Fig. 84 represents the Miller Press, which is made in three different styles for front bricks, and usually one style for fire-bricks. In this make they usually work with two levers, one to press the brick with a downward movement, and the other to raise the brick level with the top of the mould. The price of this machine on board at Philadelphia, Pa., is $145.

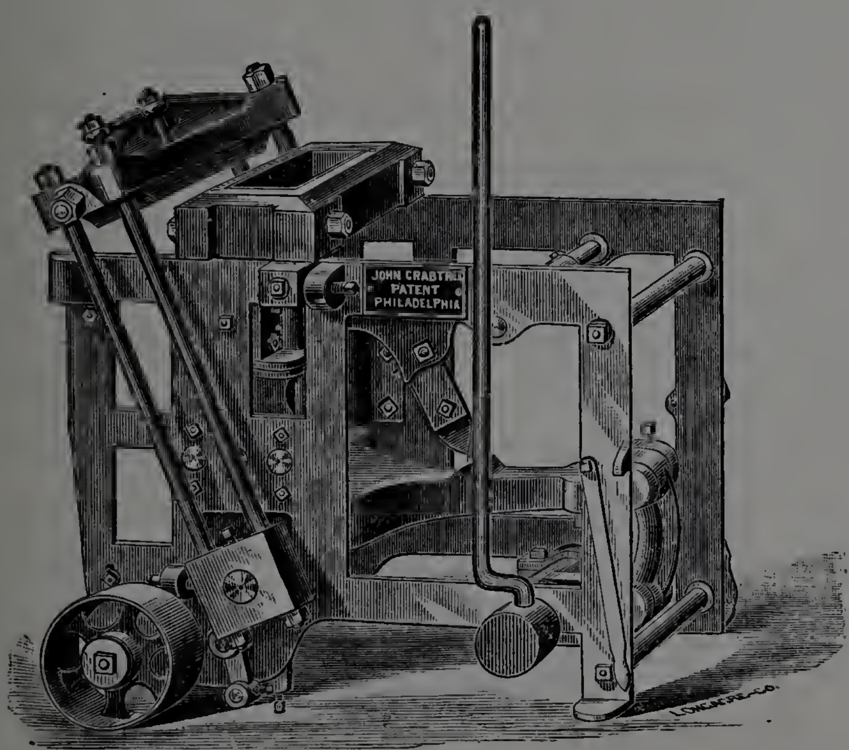
Mr. Miller invented and commenced the manufacture of his press in 1844. Not satisfied with his first attempt, he has gradually improved on it since that time, till his skill and labor have been rewarded by a machine possessing many advantages and conveniences. This machine is manufactured of the best material, and the parts are smooth and finished in a workmanlike manner, thereby aiding the operator by lessening friction. Its other advantages are many, being simple in construction, combining speed, durability, and economy. In the manufacture of red brick, its thorough work is perceptible in the handsome and even shape, uniform corners, solidity, and smooth, straight surface. In fire-brick it compresses the clay so as to give solidity. By the aid of one of these machines five thousand red bricks can be compressed in ten hours' time, increasing them largely in value. It can be operated by one or two levers, or by lever and treadle. Its construction is so plain that there is nothing complicated to get out of order, and occasion trouble and expense for repairs. There is no wood work about it, being constructed entirely of cast-steel, wrought, and cast-iron; the box-lid and plate being faced with the best cast-steel, and with cast-steel extension side around the plate. The reputation of this machine is established all over this country, and there is not a State in the Union to which Mr. Miller has not shipped more or less of them.

Fig. 85.



The well-known Carnell press, shown in Fig. 85, is made in three different styles, single lever, shown in Fig. 85, double lever, and lever and treadle. In the first style one lever presses the bricks, and raises them out of the mould-box; the second style has two levers, one to press the bricks, and the other to raise them; the third style is the same as the first, except that it has a treadle to lift the bricks. The price of this substantially built brick-press is $115, on board at Philadelphia, Pa.

Fig. 86.



The new front brick-press, shown in Fig. 86, is known as the "Peerless" press, and it is used exclusively by the Peerless Brick Co. at their extensive works near the city of Philadelphia, and was patented in 1882 by Mr. John Crab

tree of that city, and when I first saw it work was much pleased with its easy adjustment and power of execution.

The levers, operated in one direction, in connection with other appliances, serve to press the brick, while in the mould, and in the reverse direction to eject the pressed brick therefrom.

The plunger or pressing-head is so constructed that when its sides are worn it may be expanded, and thus adjusted to the proper dimensions; and the mould is also so constructed that when its sides are worn they may be removed, made true, and restored, and the size of the mould preserved.

The operation of this press is as follows: the lever is raised slightly, in order that the head may be thrown from the mould; the plunger is then at or about its lowest point, and a "glut" or green brick is placed in the mould, and the head restored to its normal condition. The lever is now lowered, the effect of which is to depress the frame to which the head is attached, and hold the head firmly on the top of the mould, the lever turning on the pivotal connections with the frame as axes, and simultaneously with the descent of the frame, the links under the frame are raised, thus advancing the plunger, and thereby pressing the brick. The lever is now elevated, thus throwing the forks of the lever by its notches on the studs as fulcrums, and lifting the frame. The head is now swung from the mould, thus uncovering the top, as shown in Fig. 86, and the lever continuing to rise, reaches and bears against the twisted leg shown at the back of the plunger, and thus raises the lever, to which it is attached, the action of which is to elevate the upper section

of the plunger to its full extent, and thereby eject the pressed brick, which may be readily removed from the top of the plunger-plate.

The stay-bolt over the top of the head is somewhat bent, and rests centrally on a bridge rising from the top of the head, and its ends are passed through the side pieces of the frame and tightened there-against by nuts, as shown in the cut. By this provision the head and frame are securely connected, and the head is vastly strengthened and enabled to endure the severe strain to which it is subjected during the pressing operation, and provision is made for tightening the parts when required.

The guides of the plunger are adjustable laterally, whereby provision is made for taking up the wear and causing the plunger to move true at all times.

When the "gluts" for pressed bricks are made by machinery the clay should be wet, and the bricks, when they issue from the machine, should be soft enough to allow the finger to be forced into them. The gangs which re-press machine-made front bricks are composed of four persons, if handled on barrows, and three if handled in the brick cars, the members of the gang being the presser, off-bearer, and rubber or sander. The bricks are run through in a hurry, three thousand being a day's work. Bricks made in this way are not usually suitable for the lower story fronts of fine buildings; but when economy is an object they can be used in the upper portions where their defects cannot so easily be discovered. This is hardly honest, but a great many neat fronts are thus put up in neighborhoods

that would not justify the employment of first quality and high-priced bricks.

When care is taken with every stage of the work, and the "gluts" are made very soft and well and thoroughly sanded and rubbed, it is possible to produce pressed and ornamented bricks which are not only good in appearance, but which are strong and durable, and which can with safety be used in place of first quality bricks for cornices and other work occupying a high position in buildings.

The illustrations, Fig. 87, show what excellent work can be done in this line of manufacture by the use of machinery, and some of the relative positions in which the different designs may be employed are also shown.

The fronts of the new buildings now (1884) in course of construction at Washington, D. C., for the Pension Office of the United States Government, are being faced with pressed bricks made by machinery. They are laid in red mortar, and the effect produced is good; the ornamentation of the building is in terra-cotta.

The bricks were produced in the city of Washington, and the enormous pressure to which they were subjected is given on page 71, to which the reader is referred for further information.

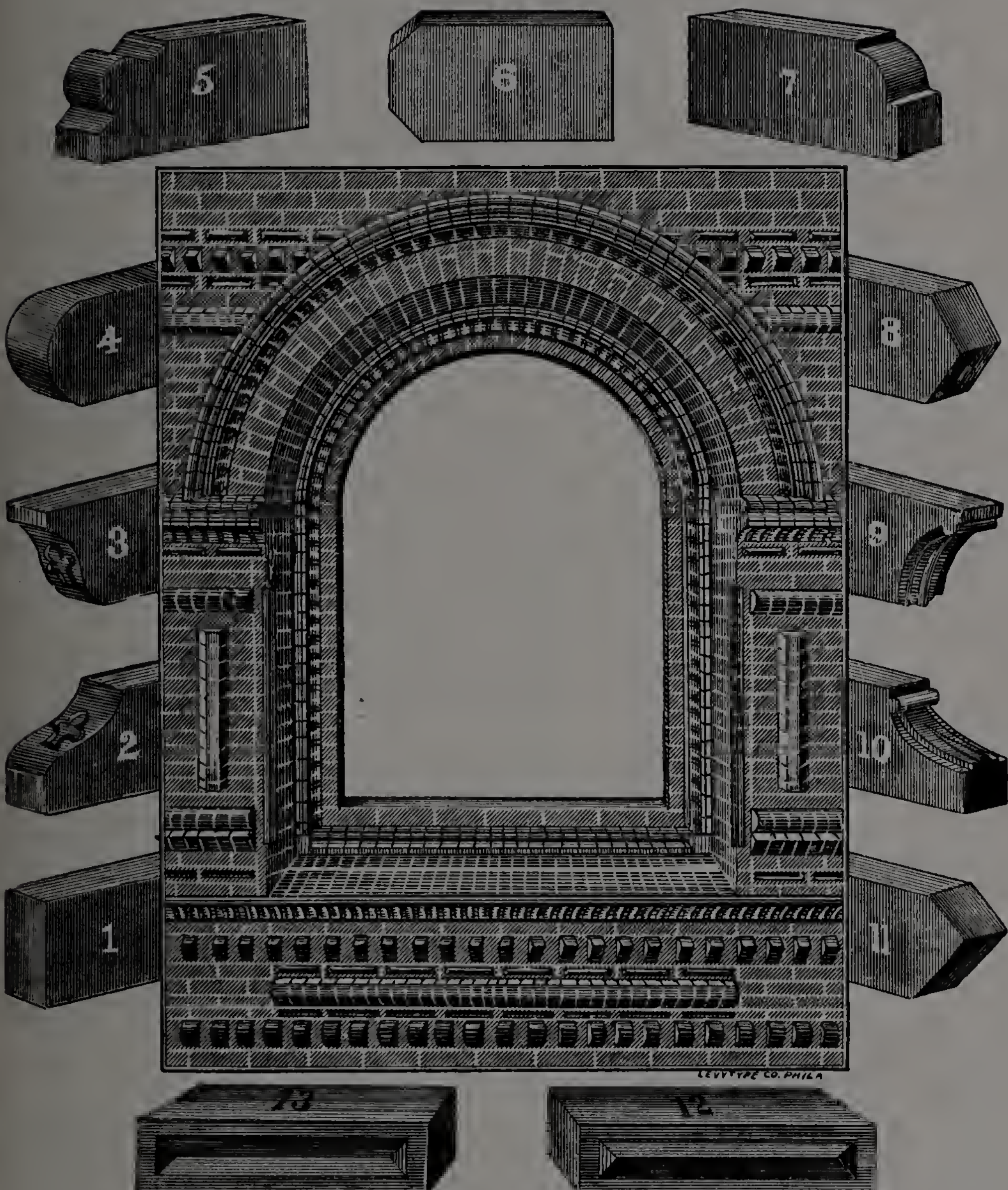


FIG. 87.—Page 230.

CHAPTER VI.

FIRE-CLAYS, FIRE-BRICKS, AND OTHER PRODUCTS, AND THE NECESSARY MACHINES, ETC.

Fire-clay is a substance which differs very greatly from the brick-clays, and also in many particulars from the terra-cotta clays; and the best fire-clay for any special purpose is that which will, for the longest period of time, effectively perform all that can be reasonably required of it, at the least cost or for repairs. Like the clays which have been named, fire-clays cannot be properly used as found; they must, as it were, be suspended in some infusible material, which will be a check upon the great mechanical effects of the heat, and at the same time concede a certain amount of expansion as well as of contraction, and exert a positive influence over both tendencies, should there be a disposition in either to go to too great an extreme.

The materials employed for this purpose are generally pulverized quartz or quartz-sand, finely ground old bricks, burnt clay, serpentine, which is a hard rock, veined or spotted, in which the colors are variously disposed, but the most prominent are greens and reds; talc, which is a mineral, occurring in granular and flaky conditions; graphite in powder, and when there is no fear from the ash, small coke

is used; but the last should be very cautiously employed, and only when graphite cannot be had, or when it is not desired to use it on account of its high price.

When a cheap mixture is to be made at the place where it is to be used, without previous burning, it is usually composed of one-fifth plastic clay, and the other four-fifths of burned clay or quartz, or it can be varied to one-fourth meagre clay to three-fourths burned clay or quartz.

The mixture avoids contraction, and is the most economical compound that can be constructed for many purposes, and it is coming rapidly into use, even for small blast furnaces that are not in constant or hard use.

The composition of fire-clays differs very materially; but those which contain the largest per cent. of alumina are the best; in these there should be not over three-fourths of one per cent. of lime.

In a large number of industries, an increase may be made in the proportion of combined silica, and thereby increase the resistance to the fire; but this will answer and perform the requirements only at a low temperature.

But the greater the per cent. of combined silica in intense heat, the greater is the fusibility, and for all ware to be so employed, the longer should be the exposure to the heat in the kiln.

The refractory power of all fire-clay wares is greatly enhanced at very high temperatures by the presence of a large per cent. of alumina.

There should be a perfect understanding of the difference between combined silica and free silica. In speaking of the

composition of fire-clays, the first, as has been stated, will melt in very high heats, in proportion to the per cent. of combination; but clean, free silica, *i. e.*, in crystals, mechanically combined, will not melt in our melting heats, unless fluxed.

Consequently, a high proportion of free silica, in the absence of a high per cent. of the fluxes, lime, magnesia, alkali, and oxide of iron, is not near so injurious as when the silica is combined. Any additions in the fluxes, above three and one-half per cent., very quickly increase the fusibility of the clay, in the order in which they have been named in the preceding paragraph. They are thought to be damaging in the following order, viz: magnesia most, then lime, next oxide of iron, and least alkali.

The average amount of alumina, silica, etc., contained in the best fire-clays may be expressed in the following table:

Alumina	29.50
Silica	58.75
Lime	.31
Magnesia	.09
Iron oxide	3.00
Potash	1.75
Soda	1.00
Water combined	11.50

There should be no organic substances.

The table is prepared for comparing the relative values of fire-clays.

All the above substances do not usually appear in good clays; in some there are none or only traces of lime and the different fluxes, and in other clays there may be a

larger or smaller proportion; but the ingredients in all good fire-clays should be somewhere in the neighborhood of the averages given above.

But, as has before been stated, any increase of alumina intensifies the resistance to heat at a high temperature; but in a combination when the alumina reaches as high as 40.5 and the silica decreases to 45, and the hygroscopic water appears in about the same proportion as the average of combined water, then the compound is probably china-clay or kaolin.

According to M. Brogniard, the clay which is most refractory when deprived of its hygrometric water has the composition: silica, 57.42; alumina, 42.58. Silica alone cannot be used unless it be ground, and, having no binding or plastic qualities like alumina, a small proportion of binding material is added to it.

For the Dinas fire-brick, which is the best substance to resist heat alone—the binding material is lime. The Dinas bricks are sometimes called "stone bricks," and are largely produced at Neath, in Glamorganshire, and are much used in the construction of copper furnaces at Swansea. The materials of which the bricks are made are from quarries in the neighborhood; there are three kinds of material, which are faithfully mixed together; the composition of the three substances is as follows:—

	From Pendreyn.	From Dinas.	
Silica	94.05	100	91.95
Alumina, with traces of oxide of iron .	4.55	traces	8.05
Lime and magnesia		traces	traces.
	98.60	100	100.00

The bricks are made from these quartzose sandstones, which are first heated in quantities of twelve or fifteen tons in a Rumford oven, and then thrown into water to break them up, and then pulverized to a coarse powder between iron rollers. The amount of lime required to bind the bricks is one and one-half per cent., and sufficient water is added to make the mass slightly cohere under pressure; the joints between the bricks when laid are filled with the same material.

These bricks expand under the action of heat, but care must be taken not to expose them to the action of slags that are rich in the metallic oxides. These fire-bricks resist a much greater heat than those made from the Stourbridge clays. The Dinas bricks will last six weeks in the roof of an ordinary reverberatory furnace at a temperature which, if it could be measured by mercury, would be about 2200° C., equal to 3992° Fahr., and in that period will be reduced from nine to two inches by abrasion of the flame and dust, and partly from chipping.

The bricks conduct the heat so badly that at this great temperature, which is a bright white heat in the interior of the furnace, the exterior is not more than pleasantly warm to the touch of the hand. These bricks are carefully dried on floors warmed by flues after being pressed; seven days' hard firing are required for the bricks, and a little longer for cooling the kiln.

The ash-dust which circulates with the gases is ordinarily a chief cause of the wasting away of fire-bricks, and in furnaces where there is no dust, such as the Siemens, they give out from weakness.

But, before describing their manufacture, and the care to be taken in their production, it may be best to examine more particularly into the causes of their destruction in various positions. This may be charged in their ordinary uses to the following agents:—

The presence of extraneous materials, such as lumps in the shape of fragments of lime, iron-stone, and small pebbles; then the behavior of the material, which at a great temperature becomes a semi-plastic red-hot or may be a white-hot mass on the interior, and the pressure from the superimposed structure distorts its form downwards and gradually squeezes out the face of the bricks, which compels the hottest portions of furnaces and kilns to be periodically relined.

The most refractory clays generally offer the greatest resistance to the action of glass, and exhibit a parallel variation in their power of resistance to slags, and are on the whole more easily attacked by slags than by glass.

When the bricks line flues and furnaces, the fumes and ashes, continuously carried into contact with the surface of the lining, bring foreign accessions, which gradually vitrify the face of the lining, and then form a viscid slag-coating. This coating slowly but surely eats into the interior of the face of the brick lining, at the same time slowly creeping downwards, and clogging the flues and fire holes with a vitreous mass.

No matter how refractory a brick is, the gradual fretting away of the surface exposed from vitrification, which is engendered, is certain, as has been explained.

The fretting away of the interior surface in blast furnaces

gradually enlarges their capacity, as the fire-bricks are eaten away; in this class of furnaces, the destruction gradually decreases from the tweers upwards, the portions opposite the impact blast being distinctly cut out beyond the outline of the enlarged circumference.

The yearly consumption of the interior brick-surface of a blast furnace in constant and hard use may be given at about from three to four inches at the tweers, and about three-quarters of an inch toward the middle of the furnace. The stability of all fire-brick masonry depends largely upon a minimum of joining material being used; for this reason, the flat faces of all fire-bricks should be exceedingly true, thereby allowing a proper jointing to be spread, which counteracts, in a very great degree, in heavy firing, the strong tendency to shatter or rupture the structure.

Too much attention is given to obtaining true faces to the edges of fire-bricks; now, as both faces cannot be usually exposed, there are two to select from in the laying, with every reasonable prospect to suppose that one of them will be good any way; but the flat surface, which is of equal importance, is left to take its chances of being regular or not. Every joint in a furnace has proportionately more to stand than a brick; if the brick be in any way rough on either the top or bottom flat surface, it will not yield to the mechanical effects of the heat, and will be gradually but certainly drawn slightly in, and be pushed very gradually back, during the heavy firing and changes of the temperature. There is no way to calculate this very small movement; but the ultimate effect is to loosen the brick, and when one is

loosened, others also gradually follow. In this manner flues are sometimes formed between the fire-brick lining and the exterior walls, resulting in great loss, as well as in vexatious delays, oftentimes in the heats.

There are some very expensive constructions of fire-brick masonry that are too carelessly erected; material is allowed to go into the work that is unsuitable in many ways, bricks varying in thickness, and with rough flat faces are hammered closely together in many places, in order to keep the work to the straight edge, or the line, which latter is often not properly tightened.

Even the tweers of great blast furnaces are often constructed in just such a careless manner, and the proprietors allow this kind of work to be hurried along and negligently done.

There is one important point that should be constantly remembered by all who employ or produce fire-clay wares of the best quality, and it is that there is not a single point in any stage of the work of either the production or the use of this kind of material that can be hurried in the slightest degree.

Large furnaces, and other important constructions, through which millions in value are to pass, are not the class of work that can be erected like the walls of an ordinary building.

In the erection of an extensive blast-furnace it should be a first requirement to have a number of fire-bricks more than sufficient to complete the work on the ground before the fire-brick masonry is allowed to be started. From

these bricks a few should be selected for tests and reductions; the bricks should then be passed through a gauge, and those of an exact thickness and having all the faces perfectly true should be culled from those which did not meet the first requirements, another lot of a uniform thickness could be selected, and so on to the end; but at all times rejecting those in which the surfaces were not perfectly smooth and true. In this way the work could be completed and the courses kept at uniform thicknesses, and good joints of mortar given, and there would be no excuse for hammering one brick down close to another.

Of all the productions from clays used in industry, except crucibles, there is not a material that requires so much, and which receives so little, inspection before use as fire-bricks.

The best classes of this material are very expensive; but either from over-confidence, or from ignorance, a very large amount of such material finds its way into many trying positions, and for which it has not the slightest capacity to fill.

The corroding influence of metals to which the material may be exposed, and that of slag which has been explained, have to be retarded by very careful preparation, and afterwards intelligent manipulation of the moulded clay to produce a denser brick as well as surface smoothness, great care during gradual drying, added to thorough and hard firing.

In some large works in Belgium, after exercising all the ordinary means and precautions to secure careful preparation and make the mixture perfect, it is submitted to a continued succession of shocks, and by long experience it has been

demonstrated that the wares so made retain their form perfectly, while bricks and other things produced of precisely the same mixture, contract.

The article having been completed from the thoroughly prepared and tempered clay, it must be again "tempered" in the drying process. The commencement of this is in the open air, but out of all draught; this should be continued for four days, and if the ware dries too quickly, pieces of dampened woollen carpet can be laid on it and occasionally lightly sprinkled with water. Then the place where the drying is conducted is slightly heated, the temperature commencing at about 75° Fahr. If carpet has been used it is allowed to remain over the wares for two days in this temperature, which is continued for thirty days, and for three days at the end of this period it is gradually increased to 90°, and then for three days to 110°, leaving the ware in this for as long as possible, all the while preserving an active ventilation from the top of the drying-room; but being very careful to keep the temperature regular. Furnaces are generally used for this drying and tempering process; but the manner is not a good one, as there are too many changes or variations of temperature, especially in the night time, and during the last six weeks, in which period the temperature should commence at 150°, and gradually increase to 190°. The many gradual increases and long periods of regular temperature can be maintained for this process only by a good system of hot-water circulation, or of steam heating, in both of which there should be an intelligent distribution of a large heating surface. For one week the final temperature

should be lowered from 190° to 90°, which completes the drying and tempering process.

It is not often that bricks require or receive much care and for so extended a period; but crucibles and retorts demand it, and the common and rapid destruction of them is largely owing to the fact that they do not get it. That this slow process of tempering greatly improves the refractory nature of the article, and that there is great economy in it, have been clearly proved by long experience. From actual experiments in crucible works it has been found that crucibles produced from exactly the same mixture, and carefully tempered for a period of from seven to nine months, last fully four times as long as those receiving only about two months of tempering.

All of which clearly demonstrates that the older and more carefully all articles of this class are tempered, the longer and more effective will be the period of their use.

An extended and thorough period of drying is highly desirable for many employments of this class of wares in zinc distilleries; as for zinc retorts, the material is simply dried, and not burned in the kiln.

Sometimes a compound composed of 36 granite, 40 white lead, 15 flint, and 5 glass is applied to the one exposed face of the ware, and converted into a glaze.

The unsuitable qualities and careless preparation of clay intended for use in this class of retorts have done much to hinder advancement, and destroy the results of experiments in the production of zinc.

Dr. Isaac Lawson had many drawbacks in his native

country, Scotland, from this cause, in experiments for the manufacture of zinc from calamine; but he finally succeeded in his invention, and by 1737 had it in successful operation in England.

The first zinc manufactured in the United States was produced one century later, in 1838, at the U. S. Arsenal at Washington, D. C., from the red oxide of New Jersey.

The zinc was for the manufacture of the brass designed for use in the standard weights and measures ordered by Congress; but the experiment was discouraging as well as expensive.

The New Jersey Zinc Co., in 1850, regularly commenced its manufacture from the ore; but from the chemical action of the ore upon the clay of the retorts, the Belgian method, which was the first one they adopted, proved a complete failure.

In the franklinite, the oxide of iron, associated with the zinc ores, formed a fusible silicate with the silex of the clay, which was extremely injurious. From about the same cause, in 1856, Matthiessen and Hegeler made as great a failure of the Silesian plan at the works of the Lehigh Co.

The experiments of John Watson, at Camden, N. J., as well as a patent obtained by John Wetherill, of Bethlehem, Penna., miscarried, mainly from the same cause.

Mr. Wetherill finally obtained a mixture of suitable clay, and by very careful preparation, drying, and tempering, upright retorts were constructed, which proved sufficiently refractory.

This stimulated the Lehigh Zinc Co.; they took a new

lease of life, returned to the Belgian furnace, and their works at Bethlehem, Penna., have since been in successful operation.

The material used in the construction of the arches, as well as walls of large glass ovens, is best produced from the Stourbridge or similar clay, which is carefully shaped into large slabs, and faithfully dried for more than a year; but it is not burned in the kiln.

As the plasticity and shrinking of clay are of importance in this line of pottery productions, probably no better explanation of these properties can be made than that given by Bischof in regard to the plasticity, and that by Aron in regard to the latter quality, and I shall embody them here:

The plasticity of clay, or its power of yielding with water a mass that may be moulded, is of great importance in a practical point of view, and interesting as a subject of scientific inquiry.

Aluminium hydrate, like silicic acid, is capable of assuming the gelatinous form, in which, owing to the peculiar arrangement of the atoms, these compounds are able to take up a large quantity of water, swelling out to an extraordinary degree, and thus enveloping or binding together sandy or earthy matters in a fine state of division. On removing the water by drying, the original plastic mass shrivels up; this is termed shrinking.

Either on drying in the air, or on burning, the atoms of clay approach one another more closely, the accompanying admixed constituents also at the same time being drawn together.

An increase of density and diminution of bulk thus occur.

The capacity for absorbing water in different clays varies as greatly as their plasticity, which increases with their power or tendency to crumble (possibly with the formation of aluminium hydrate). Meagre clays readily absorb water, and attain the desired degree of plasticity; "fat" clays, on the contrary, become very friable. The former become softer by working, the fat clays stiffer. Many fat clays exhibit the phenomenon technically known as "water stiffness," *i. e.*, when softened with a certain quantity of water, they have no inclination readily to absorb more.

Shortness or meagreness depends more upon the presence of undisintegrated mineral particles than on that of sand; a clay rich in sand may, however, be fat, but one rich in unreduced mineral matter never can be.

By gradual drying at a temperature increasing to 130°, the weighed portion of clay being placed upon a glass plate, and two parallel marks cut upon it, and the distance between the marks repeatedly measured, it was found that the shrinking did not continue until the clay was quite dry, but ceased before this point was attained.

To a certain point, the shrinking exactly expressed the loss of water; at this point, it suddenly stopped, just as the clay particles came into contact. Aron terms this point the "limit of shrinking," and distinguishes the water dissipated to this point as the "water of shrinking," and that subsequently driven off as "water of porosity." The sum of the two is total water.

The cubical amounts of shrinking of a pasty mass of clay were found to be equal to the volumes of water evaporated. The proportion of pores in the dry clay is constant, *i. e.*, independent of the water originally contained. From the fact that the proportion of pores in several chemically different clays is nearly equal, it may be inferred that the smaller atoms of clay have a regular spherical shape. This view is confirmed by microscopic observations.

In a plastic mass of clay there is thus a vast number of these little spheres at equal distances, suspended in water. The distance between these particles is so small that the attraction between them is considerable, and so a system of capillary tubes is formed, in which the expulsion of water by pressure is so opposed, that neither the power of attraction of the spherical atoms for one another, nor their vertical downward pressure, will permit the water to penetrate through the tubes. Plasticity commences with increase of the distance between clay atoms, and ceases when that increase has attained a certain amount. In shrinking, as water evaporates on the surface, a fresh supply is drawn from the interior of the mass through the fine capillary tubes mentioned above, the particles approximating throughout the whole mass, in obedience to their power of attraction; and this process continues until the atoms come into contact, and then room for water is afforded only in the spaces between the particles (water of porosity). In meagre clays these fine spherical atoms envelop the irregular-shaped particles of foreign matter. On trying the effect of additions of very fine sand to some washed clay, it was found

that, to a certain point, the shrinking power of the clay increased with its progressive meagreness (the water being constant), and the porosity decreased. This point is termed the "point of greatest density" of the mass.

From the point of greatest density, further impoverishing diminishes the shrinking for an equal amount of water in the pores, but increases the porosity.

Sometimes refuse materials may be converted into a passable quality of fire-bricks; the material alone has no plasticity, but possesses quick drying qualities.

The refuse from the China-Clay Works of Devonshire, in England, is satisfactorily used for this purpose. After the kaolin has been washed out, the quartz and mica are mixed with a small portion of fat clay, thoroughly tempered in the pug-mill, and moulded into bricks. They are found to resist the effects of heat very well, and are commonly employed in the construction of some classes of metallurgical works.

In England, the lining for Bessemer convertors is often produced by mixing pulverized Sheffield sandstone with two and one half per cent. of alumina and oxide of iron.

The introduction of the Bessemer process for the manufacture of cast-steel, and of the Siemen's gas-furnace into countries which are but poorly supplied with fire-resisting materials, has developed the difficulty of securing bricks of a sufficiently refractory character to withstand the extremely high degree of heat exhibited in the melting chamber, as well as the sudden, and often violent, alterations in various other portions of the furnaces.

In many portions of this country and in England, there

is not a great deal of trouble in meeting these demands; but in supplying less favored countries and colonies, Mr. Joseph Khern, the well-known Austrian metallurgist, gives a method for obviating this difficulty.

The plan which he has introduced for the manufacture of these silicious bricks is an excellent one, and the material produced he describes as being much superior to any other refractory product obtainable in Austria.

The chief ingredient employed is quartz, which must be of the highest degree of purity, especial care and watchfulness being exercised to reject all such portions as show any admixture of iron or copper pyrites, carbonate of lime, or even mica or feldspar. The preparation is similar to that observed in the manufacture of Dinas, and the silicious fire-bricks made at Stolberg, near Aix.

The quartz, having been selected in the manner described, is heated in quantities of from twelve to fifteen tons in a Rumford oven, or a continuous kiln as for lime may be used. At the end of twelve hours, having reached a full red heat, it is thrown into water; the best fragments are then selected and afterwards cleaned by a simple jigging process, and then subsequently crushed under a tilt-hammer until sufficiently fine to pass through a sieve having sixty holes to the square inch, which leaves the particles coarse and sharp.

Two varieties of fat clay are used to bind the coarsely-pulverized quartz; the clays differ slightly in plasticity, and are very carefully prepared by thorough weathering, pulverization under light stamp heads, and fine grinding under

edge rollers; a final sifting is performed through a very fine sieve of six hundred apertures to the square inch.

The tilt-hammer used for pulverizing the quartz weighs two hundred and fifty pounds, and is capable of crushing three and one-half tons of the burned quartz in twelve hours.

In selecting the quartz the purest quality is reserved for the first quality of bricks, which have to resist the greatest temperature and sudden changes; while the second and third classes of bricks are made for less exposed positions, and are composed chiefly of the remains of bricks which have been once used, but again pulverized and sifted afresh.

The following are the compounds employed for the different classes of bricks: First class, 16 parts of quartz to 1 of plastic clay, or 14 parts of quartz to 1 of leaner clay: Second class, 16 parts of ground bricks of the first class to 1 of clay: Third class, 8 parts of ground bricks of the second and third classes to 1 of clay.

The third class bricks are made more with an idea for their employment in portions of the furnace requiring greater mechanical strength than fire-resisting qualities. The materials are first mixed together in a dry condition on a large, clean, and tight platform of wood, and are then thrown into a tight wooden pugging-box, six feet square and nine inches deep. In this box the dry mixture should be about six inches deep, and be thoroughly incorporated by kneading with water and treading under men's feet, and occasionally turning over the mass with shovels, care being taken not to draw splinters from the wooden box into the

clay. A sufficient quantity of water must be added to allow the mixture to be worked into a ball between the fingers without crumbling.

The second and third class bricks are formed in open moulds, the pug being beaten down by a metal rammer of about four and one-half pounds weight; the first class, however, are subject to a pressure of about three and one-half tons to the square inch during a period of three-quarters of an hour before they are removed from the moulds.

The drying is done in chambers through which a current of air passes, at the ordinary temperature in summer, but artificially warmed in winter. The bricks are fit for burning in seven days. The kilns are rectangular chambers, each having two step grate fireplaces in one of the shorter sides, and a flue communicating with a high chimney at the opposite end. The capacity is small, being only about twenty-five hundred bricks. As soon as the kiln is filled the charging opening is partly closed, and a gentle fire is kept in the grates, the damper in the flue being closed.

At the end of thirty-six hours the charging hole is entirely closed, and the draft is stimulated by opening the damper in the flue inch by inch at intervals, until at the end of seventy-two hours the whole of the bricks have attained a strong white heat. The fires are then removed, the damper closed, the grates filled with sand, and cracks that may have been discovered in the kiln are carefully luted or smeared over with soft mud.

The charging opening should also receive careful attention and be faithfully daubed. After standing in this way

for thirty-six hours, the charging place is gradually opened, and in from sixty to seventy-five hours the burned bricks may be removed.

In the United States, superior qualities of fire-clays are found in various localities. The fire-bricks most esteemed are those made from the "Amboy clay" of New Jersey, and the Mt. Savage fire-bricks made at Mt. Savage, Md. The first are produced from a cretaceous clay, which is first burned in a kiln, its plasticity being lost in the process, and resulting in what is known as "cement;" the second or Mt. Savage bricks are produced from two qualities or varieties of carboniferous fire-clay, one of which has in its natural state the properties of the "cement" just mentioned. It is non-plastic, and is treated in the same manner as the "Amboy clay."

At Mineral Point, Tuscarawas County, Ohio, a clay nearly similar to the Mt. Savage clay is found; its appearance and properties are about the same; it is non-plastic, and is treated in the same manner.

For all these clays the "cement" is coarsely ground, mixed with from one-sixth to one-tenth plastic clay, gradually dried and tempered and then hard-burned.

The fire-bricks made from the clay of the coal-measures of Pennsylvania, Ohio, Illinois, and Missouri are also held in high esteem. In some portions of the State of Michigan a very fair quality of bricks is produced from non-plastic clays.

Cheaper bricks, and of somewhat inferior quality, but yet adapted to many purposes for which fire-bricks are used, are

or may be made in a great number of localities, as reasonably good fire-clay is an abundant substance in this country.

Fire-clay beds are fine sediments which accumulate at the bottoms of shallow pools of water, subsequently filled up with growing vegetation.

The roots of aquatic plants have penetrated this clay-bed and extracted generally its potash, soda, lime, iron, etc., and have removed such a percentage of silica as to leave it with a larger relative quantity of alumina than it had before being subjected to their action. In this manner they have extracted from it its more fusible or fluxing ingredients, and have left it its peculiar property of remaining unchanged at a high temperature.

Many beds of peat have underlying them clays very like our fire-clays, and in such circumstances we may plainly see the formation of fire-clays progressing.

In this country we have two varieties of fire-clay, the one non-plastic and particularly adapted to the manufacture of first quality of fire-bricks, and the other plastic, and used for the production of an inferior quality of fire-bricks, and the production of pottery, terra-cotta, glass pots, etc.

In the first class are those that have been mentioned, to which should be added that at New Lisbon, Ohio. To the second class belong the fire-clays of the coal-measures, which differ greatly among themselves as regards purity and excellence, but which answer for secondary purposes, and are very extensively employed in the manufacture of all classes of terra-cotta and stone-ware.

The analyses given below are of some of the best known qualities of fire-clays. No. 1 is of the Strourbridge clays of England, to which reference has several times been made in this chapter. No. 2 is from Mt. Savage, Md., No. 3 is from Mineral Point, Ohio; both of the last-named being non-plastic. No. 4 is from Port Washington, Ohio, and No. 5 is from Springfield, Ohio, the two last-mentioned being plastic clays.

Analyses of Fire-Clays.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Alumina	19 to 38	35.90	37.80	33.85	21.70
Silica	63 to 70	50.45	49.20	59.95	70.70
Iron Oxide	2 to 0.7	1.50			
Lime	0 to 0.7	0.13	0.40	2.05	0.40
Magnesia	0 to 0.2	0.20	0.10	0.55	0.37
Potash	0 to 0.3				
Water	10 to 16	12.74	11.70	5.34	5.45

For analyses of the English Dorsetshire and North Devonshire fire-clays, see chapter on Terra-Cotta.

To be acquainted with the chemical qualities of the fire-clays is of course useful in their manipulation; but the physical tests of this class of clays are of vastly more importance; analyses answer well for comparisons in theory; but the physical trials and results are the ones which govern in their employment in industry.

The properties of bodies largely depend upon the mode of grouping of the atoms; clays may be of the same chemical constituents, and yet when put to the physical test be of

directly opposite refractory qualities; while clays of greatly different composition may prove to be about equally refractory. The practical manufacturer does not usually care at all about the chemical constituents or composition of fire-clays; he seeks, or should seek, for that material which yields the best results in actual use.

If he wants a brick to yield slowly to the corrosive influence, which has been explained in this chapter, a simple test to apply is, to see the number of times in which it can be melted with oxide of lead and not be eaten through. In fire-brick constructions the use of joints of clay containing free silicic acid (quartz) should be avoided, which can be done by previously saturating the material with a basic burt clay.

For practical purposes the relative proportions of alumina and silica, which some manufacturers have laid such undue stress upon as indicating heat-resisting quality, are of but small moment, as both these constituents, whether occurring in combinations or as silicates of alumina, or as free alumina and silica, are essentially the real refractory elements of good fire-bricks; being unvitrifiable of themselves excepting when associated with the alkalies, lime, or oxide of iron.

The plastic character of refractory clays has also but limited influence on their suitability for fire-brick manufacture when the bricks are properly moulded, excepting extreme plasticity, which is usually accompanied by excessive contractibility and vitrifiability, which are of course very prejudicial. Take it as a general rule, but few clays or materials used in the production of fire-clay wares are either

over-plastic or insufficiently plastic to prevent their being moulded by the dry-clay process out of nearly dry pulverized clay. If too plastic, they can be dried by the wind or sun, which greatly lessens their plasticity; if this is not sufficient, the clays can be burned in an oven or kiln, and those which are not plastic can be lightly sprinkled with water before being subjected to pressure. I have in Chapter V. strongly opposed this process of manufacture for all bricks to be used for purposes of engineering or architectural construction, where strength is an essential; but the present is a very different employment, the quality here necessary not being strength, but resistance to heat.

Many clays which have but poor refractory qualities when tempered in a pug-mill can by this process of dry-clay moulding be greatly improved; the clay should be thoroughly dried in thin layers, in the sun if possible, before pulverizing. Refractory clays of still lower grades may be greatly improved, so as to resist a very high temperature, by treating with acids, and then thoroughly drying and afterwards moulding them by the dry-clay process.

There is a preponderating quantity of silica in the English coal-measure fire-clays when compared with the tertiary clays of Devonshire and Dorsetshire, in which a larger proportion of alumina appears, as is shown by the analyses of a great number of these clays.

We find coupled with the latter property, in the tertiary clays, tenacity and plasticity, and necessarily greater contraction both in the processes of drying and burning, and when this is excessive the shrinkage is curtailed by a tho-

rough incorporation with clean sand, burned clay which has been pulverized, or sherds. About two per cent. is the average shrinkage during burning of the bricks made from the several coal-measure fire-clays; this percentage of contractibility of course excludes that which occurs during the process of drying. The bricks which formed the basis of the calculation from which this average was computed, were made from nearly dry pulverized clay.

The average contractibility during the process of burning of the fire-bricks produced from the tertiary fire-clays is very much greater than that of the coal-measure clays.

Tenacity of texture in a fire-brick material is a mechanical condition, which, *cœteris paribus*, assists vitrification, a coarse open body being much more refractory than a close homogeneous brick of similar composition.

A well-manufactured fire-brick should be of a pale cream or clear buff color, uniform throughout its mass, and burnt to the full extent of its contractibility.

The chemical changes which take place in the burning consist, first, of the destruction of the disseminated carbonaceous matter, the dehydration of the silicates of alumina, destroying their plastic character, and the decomposition of the disseminated carbonate or protoxide of iron, converting it into anhydrous sesquioxide, to which the yellow color of the burned bricks is due.

Should the burning be carried to a very high state of vitrification the yellow tint is replaced by a dull gray, due to the partial reduction of the sesquioxide of iron and its conversion into silicate of protoxide or minutely disseminated

particles of metallic iron. Any alkalies also present form vitreous combinations with the silica during the latter stages of the burning.

But the paleness of color of a fire-brick is not at all times a safe indication of the absence of iron, as the presence of a large proportion of carbonaceous matter in the clay tends to bleaching by the reduction of the coloring sesquioxide to lower oxide preserved as a silicate in a comparatively colorless condition. Then, again, the presence of lime and the other alkaline earths, which are disadvantageous fluxing elements, will check the coloring power of a large percentage of oxide of iron by the formation of a pale double silicate of lime and iron. This is largely taken advantage of in the manufacture of buff-colored building bricks, and I am also very sorry to add in the production of buff-colored terra-cotta, by mixing ground chalk with ferruginous clays which would otherwise burn a dark red color.

A properly burned brick, uniform throughout its mass, can be obtained only by very slow progressive firing; a broken brick which has been too quickly burned, though pale on the surface, presents a darker central patch and concentric rings of various shades of color, due principally to the different states of oxidation of the iron, and partly to the presence of unconsumed carbonaceous matter; but the chemistry of this color diversification is not perfectly known.

In Great Britain the association of coal with the fire-clays of the carboniferous formation has localized the manufacture of fire-bricks, and by far the greater proportion are produced in the coal-measure districts, especially at Strour-

bridge, justly celebrated for producing a highly refractory brick, Brosley, Benthall, Madeley, and Coalbrookdale in the Shropshire coal-field, and in the Midland, Yorkshire, North and South Wales, Durham, and the Scotch coal-fields; but in recent years the area of fire-brick manufacture has greatly broadened.

There has been since 1850 an extensive production from the eocene clays in the neighborhood of Poole and Wareham in Dorsetshire; and a much more limited supply from the miocene between Bovey Tracey and Newton Abbot in Devonshire.

At a still more recent period Cornwall has become the seat of the manufacture, where, as at Calstock, Tregoning Hill near Breage, St. Ednor near St. Columb, and Lee Moor, fire-bricks of good quality are made from china-clay refuse and disintegrated granite, as has been before observed in this chapter.

Cornwall was one of the first seats of china-clay mining between the years 1730 and 1750, and in 1862 the Tregoning Hill Co. commenced to make fire-bricks and tiles from the refuse of the clays, taking about two-thirds of silica and one-third of mica, which are mixed thoroughly in a pug-mill, moulded by hand, and then burned in round kilns, holding about sixteen thousand bricks. A very superior quality of bricks is made from the "slopes" which are used by founders, smelters, gas companies, etc., the source of the material being the decomposed granite of which the Tregoning Hill consists. The Hingston Down fire-clay deposit, near Calstock, supplying the Calstock fire-brick

works, the Phœnix works, and the Tamar works, in the same neighborhood, consists of a range of decomposed granite, with an average width of three-quarters of a mile, running east and west for three and one-half miles, extending to an ascertained depth of from three hundred and fifty to four hundred feet, and intersected by mineral lodes. The Calstock Fire-Brick Co. commenced operations in 1870, and produced from this decomposed granite, fire-bricks of a very superior and highly refractory character.

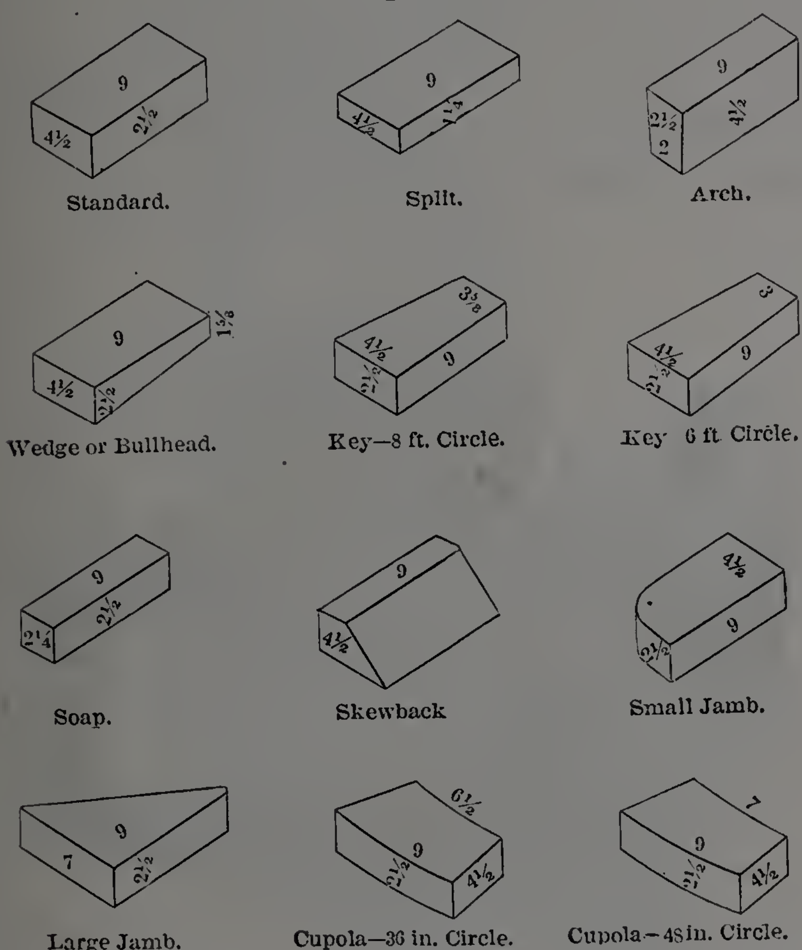
Another large source of fire-brick material in Great Britain, although scarcely yet developed, but which, in the near future, is certain to become a great field for the manufacture of fire-brick and fire-clay wares, is the immense pockets or depressions occurring in the mountain limestone of North Wales, Derbyshire, and Ireland, containing white refractory clays and sands, the insoluble remnants from the local dissolution of the limestone, intermixed with the *débris* of the overlying mill-stone grit. The highly refractory character of this immense deposit of fire-clay material makes it pre-eminently desirable for the manufacture of all the products from fireclays. Works are already established in the neighborhood of Mold; others are soon to follow. They mix these clays and sands evenly, and find them sufficiently adhesive to be moulded, and their contractibility is small, both in the drying and during burning.

Fire-bricks are made of many different sizes and shapes, as shown in Fig. 88, where the usual measurements and names of those in common use in this country are given.

The manufacture of fire-bricks may be divided under the following heads, viz:—

Preparation of Materials.
Moulding.
Drying.
Setting.
Burning.

Fig. 88.



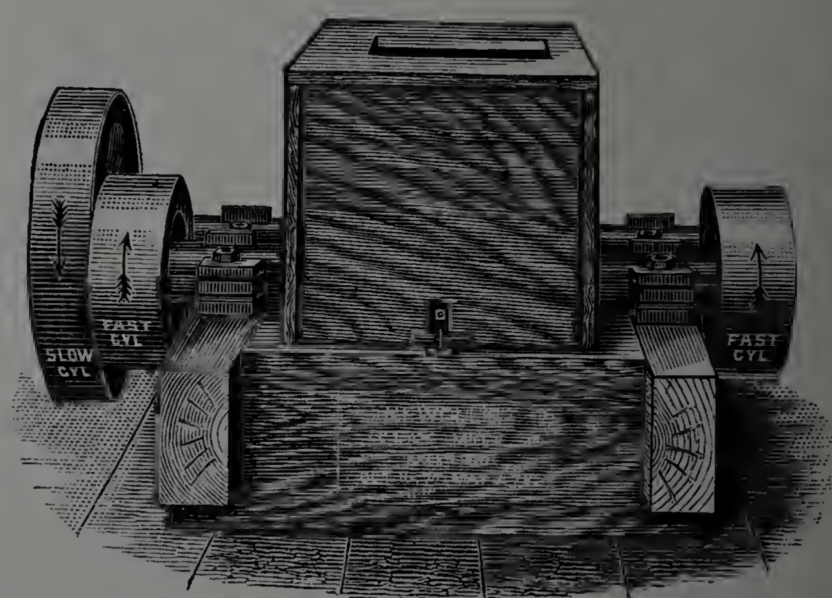
But, as all the above stages of manufacture have already been elaborated upon, we shall curtail somewhat their further description.

The "preparation of the materials" consists, after obtaining and overhauling the fire-clays, in pulverizing, mixing the various clays and additional substances in a dry condition, and then grinding with water in a pug-mill, if moulded in a tempered condition, and if moulded in a dry state, then simply in the drying, mixing, and pulverizing.

The clays which are too plastic are burned in the kiln or oven, as has been explained in the description of the "Amboy Clay," and the Mt. Savage, Md., clays.

A large number of machines are made for stamping, grinding, and tempering fire-clays; sometimes the last two operations are conducted by the same machine.

Fig. 89.



In Figs. 89 and 90 are shown exterior and interior views of the Newell mill, which is a contrivance for grinding fire-clay, and, in fact, all varieties of clay, which, as shown in Fig. 90, consists of two rollers; these run together at different speeds, so that the grinding is effected by the material pass-

ing between them, and they receive the clay just as it is dug from the pit and disintegrate it completely; and at the same

Fig. 90.

time mix thoroughly any sand, or other material that may be added to it. The work is so thoroughly done, that the

ground clay can pass directly, either by chute or on an endless belt or conveyer, from the mill to the pugging cylinder. if for fire-bricks, or to the brick or tile machine, as the case may be. The grinding is done very rapidly, and much better, than under the old methods, and with less power.

The grinding surfaces are steel castings, which are easily renewed when worn, and, as seen in Fig. 90, the cutters are fitted to a pulley or drum which is secured on the mill shaft, and when the proper number of cutters are placed on the drums they are firmly retained by two flanges with four bolts in each, as shown.

These mills are made in four sizes, which have capacities ranging from 40 to 250 tons of clay per day, and the prices on board at New York City are $300 for the small mill, increasing slightly in proportion to the other sizes.

I have seen these mills in operation performing highly satisfactory work in different fire-clay works, as well as in the terra-cotta works at Perth Amboy, and the extensive ornamental brick-works of the Peerless Brick Company in Philadelphia.

Fig. 91 shows the Carnell stamping mill for fire-clays, the price of which is $300 on board at Philadelphia, Pa.

The Holland mill shown in Fig. 92, for the reduction of hard clays, can be made stationary or portable, as is shown.

The object is to provide a simple machine that can be constructed at a comparatively small cost, not liable to get out of order, and that will with rapidity reduce the particles of clay.

Heretofore this class of machines for grinding fire-clay has consisted of a revolving pan or table for receiving the mate-

Fig. 91.

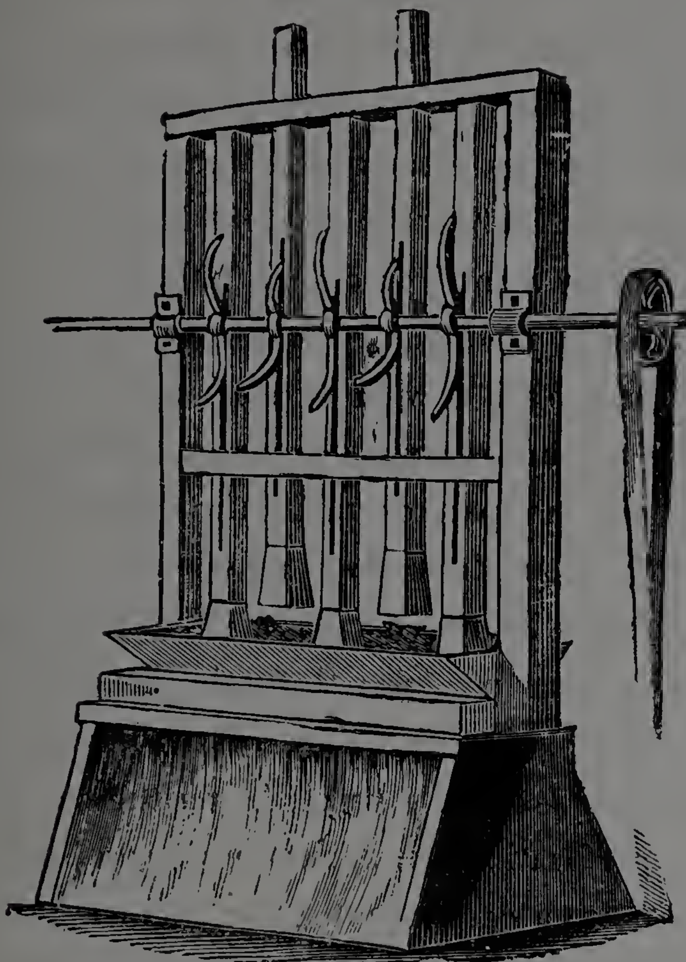
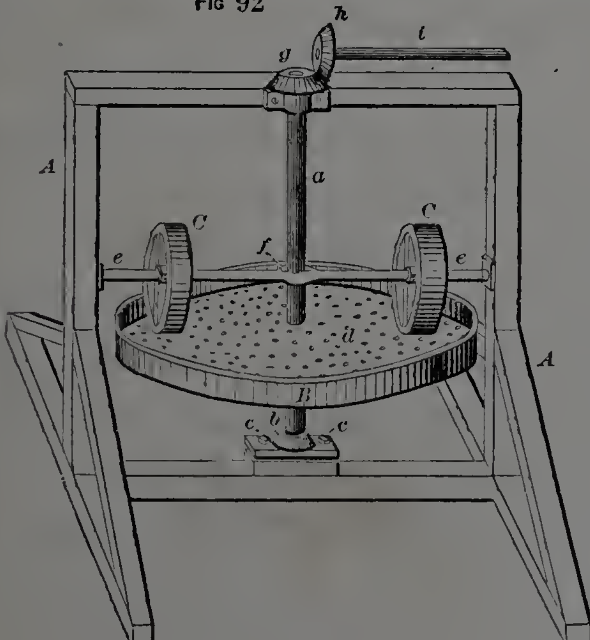


Fig 92



rial to be ground, which was reduced to fine particles by crushing-rollers revolving around a stationary and horizontal shaft. Although the material was ground to the necessary fineness, there were no means of separating the finer particles from the coarser while the process of grinding was going on, the pan having a solid or closed bottom.

Another form of machine is in use in which the pan or table, although provided with a perforated bottom, is stationary, while a shaft carrying crushing-rollers horizontally revolves around the pan or table, the rollers at the same time revolving upon their own axis. This pan or table, being stationary, will not act as a sifter for the clay, the passage of the finer particles through the perforations depending entirely upon the action of the shaft and rollers, which is not sufficient; the result being the occasional clogging of the perforations, and thus rendering the operation of the machine to a certain extent impracticable.

Holland's invention removes these objections, by providing the pan with a perforated bottom and connecting it with suitable mechanism, whereby it is given a horizontal rotary motion to sift the particles as they are reduced to the required fineness through the perforated bottom, and, as previously stated, rendering the machine practicable and effective, and at the same time not expensive.

In Fig. 92, which shows a perspective view of the machine, *A* represents the frame, of any suitable construction, to which is connected the vertical shaft *a*, the upper end thereof having its bearings in the cross-beam of the frame, and the lower end resting in a step *b*, which is preferably

made adjustable vertically by set-screws *c*, so as to accommodate it to the wearing of the end of the shaft *b*. This shaft has connected to it a pan *B*, with perforated bottom *d*, the pan, if desired, being secured to the shaft by a set-screw, and collar formed around the central opening through which the shaft passes.

The shaft *e* is formed with a yoke *f*, through which passes the shaft *a*, thus assisting in supporting the shaft in a vertical or upright position.

To the upper end of the shaft *a* is keyed a bevel-gear wheel *g*, for engaging with a similar wheel *h*, upon the end of a horizontal driving-shaft *i*, receiving its motion from suitable gearing of an engine or other power.

The pan *B* being filled with the desired quantity of clay, and the shaft caused to rotate by the gearing *g h*, as the pan turns with the shaft it causes the rollers *C* to revolve in opposite directions by the frictional contact with the clay, which is properly crushed, and which clay, when reduced to the required fineness, falls through the perforations in the bottom *d*.

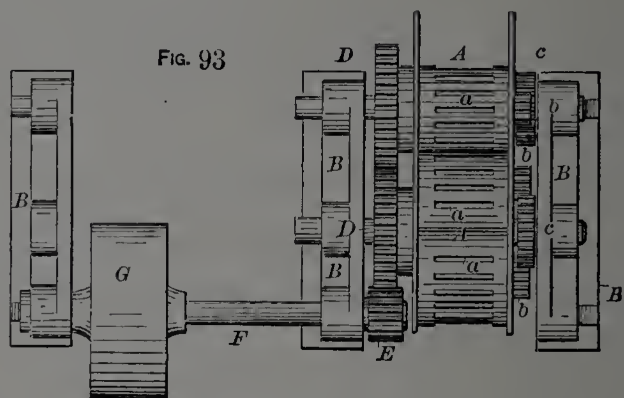
If desired, the clay may be a second time subjected to the grinding process, or as often as found necessary, and may be dumped into the pan by a suitable elevator or any other means found preferable.

The rollers *C* may be of any desirable width and size. It is preferred, however, that their periphery be as broad as possible, so as to have as great an area of surface from the centre to the periphery or rim of the pan as possible to facilitate the process of grinding.

This machine would be especially useful in preparing

the fine material necessary in making substitutes for Dinas bricks; which method is fully described in this chapter.

The clay mill shown in Figs. 93 to 97 is a good contrivance for both the mixing and reduction of fire and other clays, and will work them into either a fine, semi-fine, or coarse condition.



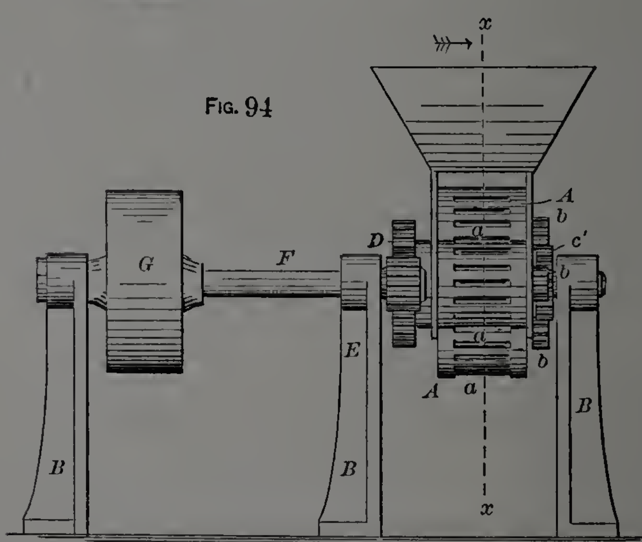


Figure 93 is a top or plan view of the machine. Fig. 94 is a side elevation. Fig. 95 is a sectional view on the line $x\ x$ of Fig. 94. Fig. 96 is a top view of one of the crushing-rollers, with a portion broken away to show the cutters located therein. Fig. 97 is a side view of Fig. 96, showing the operating mechanism.

Referring to the drawings, *A* designates the reducing-rollers or cylinders, mounted in suitable frames or supports, *B B*. The reducing-rollers *A A* are mounted so as to revolve in opposite directions, as indicated by the arrows. The invention consists in subjecting clay, clay shale, etc., to the disintegrating and reducing action of rollers having a varia-

FIG. 95

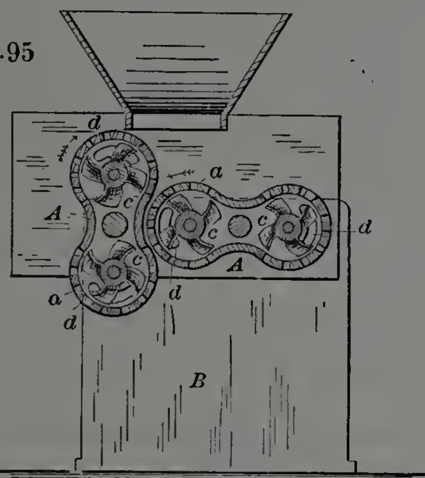


FIG. 96

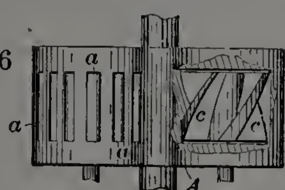
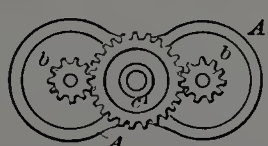


FIG. 97



ble peripheral outline, so that the clay to be operated upon will be subjected to rapid peripheral action of one coming in contact with the less rapid peripheral action of the axis of the adjacent roller. It also consists in providing the crushing-cylinders with peripheral slotted perforations, through which the clay is forced by the pressure and abrading action

of the rollers into the interior of the cylinders and subjected to the action of cutters or beaters; also of knives or beaters located within the disintegrating-rollers, whereby the clay which is forced through the peripheral openings of the rollers is still further reduced.

It is well known that it is practically impossible to reduce or disintegrate clays or the harder clay shales, by impingement alone. Pressure exerted in two directions, as in the case of two impinging rollers rotated at the same speed, only flattens or flakes the clays without disintegrating them. Even the hardest rock or quartz resists, to a greater or less degree, disintegration by such means, while by the action of this and the following machine the clay or other material is subjected to a rubbing action between the impinging surfaces, while a part thereof is forced into the slotted openings, to be acted upon by the rapid-rotating knives or beaters, and is effectually reduced to the required condition.

The periphery of a roller travels faster or has a greater velocity than the axis. Consequently, when the clay is caught between the rollers, it is subjected to the action of the periphery of the roller acting against the centre of the adjacent one. The effect will be a rubbing or abrading action, which will thoroughly disintegrate the clay, and not crush or compress it only, which is the action of ordinary reducing-rollers. The rollers *A* are provided with a series of slots or perforations, *a*, in their peripheries, which extend through the same and open into the interior of the cylinders, and through which the clay is forced to be operated upon by revolving knives or beaters located within the rollers.

C C are the cutters, arranged spirally on and around a common centre or hub, which is mounted in bearings in the ends of the cylinders *A*, and are provided with pinion-wheels *b b*, which mesh with a larger pinion-wheel, C^1, secured to the central shaft or axis of the rollers or cylinders *A*, so that by the revolution of the cylinders *A* the knives *C* will be rotated with greater velocity, and the clay which has been forced into the rollers through the slots *a* will be cut or sliced into minute particles, and owing to the spiral position of the knives, the prepared clay is thrown to one end of the cylinders and out through the openings *d*, arranged for that purpose.

The cylinders *A A* are provided with pinion-wheels *D D*, which mesh with each other and with a pinion-wheel *E*, on the main driving-shaft *F*, said driving-shaft being mounted in suitable bearings, and provided with a pulley-wheel *G*, or other means for imparting power to the machine.

H is the hopper through which the material to be disintegrated is fed to the rollers, which may be made adjustable by any of the well-known means, so as to reduce the material to any desired degree of fineness.

Figs. 98 to 100 show a modification of the clay mill above described, and it is by the same inventor.

Fig. 98 is a side elevation. Fig. 99 is a top view. Fig. 100 is a detached view of the crushing or reducing-rollers.

Referring to the drawings *A A* designate the reducing-rollers, mounted in a suitable framework *B*. The reducing-rollers *A A* are made elliptical in peripheral outline when

mounted to rotate in opposite directions, as indicated by the arrows in Fig. 100, such elliptical form compensating for the convergence incident to the changing or alternating po-

Fig. 98

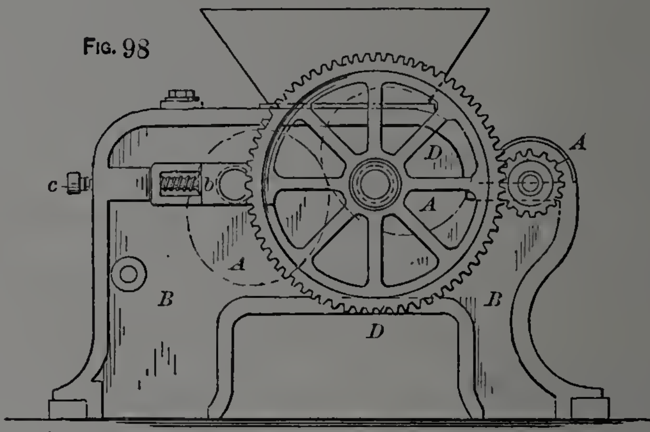


Fig. 99

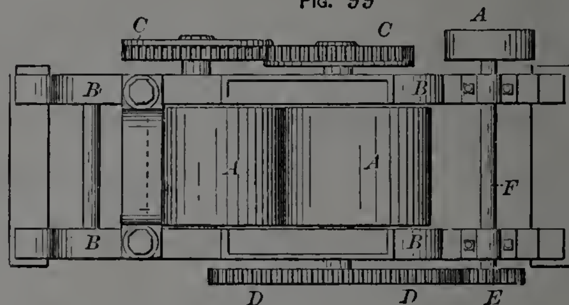
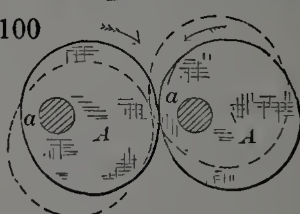


Fig. 100



sitions of the rollers when rotated in this direction, and are hung in proper bearings at a point eccentric to their axes, and so timed that when they rotate at the same velocity the faces or peripheries of each of the rollers will constantly touch or impinge against each other during their respective rotations, so that a rapidly-changing peripheral speed is given

the rollers at their points of contact, and the material to be acted upon is subjected to a rubbing, abrading, and crushing action, which reduces or pulverizes the same. The rollers should be made elliptical and rotate in opposite directions, as shown; but they may be perfectly round and hung eccentrically to their axes and rotated in the same direction, or the peripheral outline changed to produce the desired result and the rollers hung on their axes. By the action of this machine the clay or other material is subjected to a rubbing action between the impinging surfaces of the rollers, which disintegrates and reduces the material to a fine, or any desired condition.

The rollers *A A* are provided with pinion or gear-wheels *C C*, of the same size, so that they will be driven with a regular and uniform velocity. One of the rollers *A* is also provided with a pinion or gear-wheel *D*, which meshes with, and is driven by a pinion-wheel *E*, on the main driving-shaft *F*, driven by a belt passing over the pulley *G*, and connecting with any suitable source of power. One of the rollers *A* is also mounted in movable bearings *b*, which are operated by set-screws, so as to regulate the distance between them to suit the material to be operated upon and regulate the degree of pulverization to which the substance is to be brought.

The Hoxsie and Pifer machine shown in Figs. 101 to 105 is shown rigged for disintegrating brick-clays; but it can easily be converted into a valuable mill for either mixing or reducing terra-cotta and fire-clays.

Fig. 101 is a vertical sectional view. Fig. 102 is a side

view. Fig. 103 is an end view. Fig. 104 is an end view, showing the slide-boxes for adjusting the crushing-rollers; and Fig. 105 is a perspective view.

A represents the frame of the machine, which is provided at the ends with bearings for two sets of crushing-rollers *B*

Fig. 101

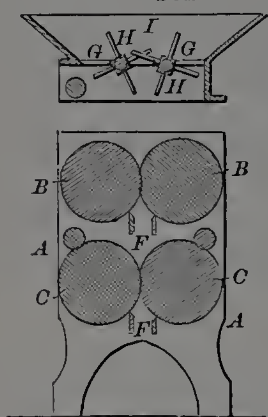


Fig. 102

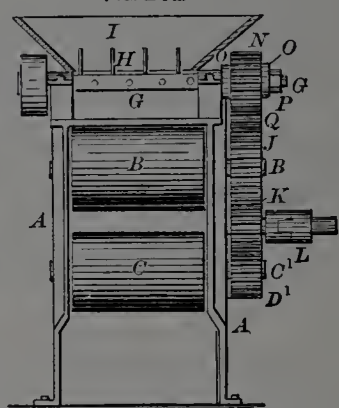


Fig. 105

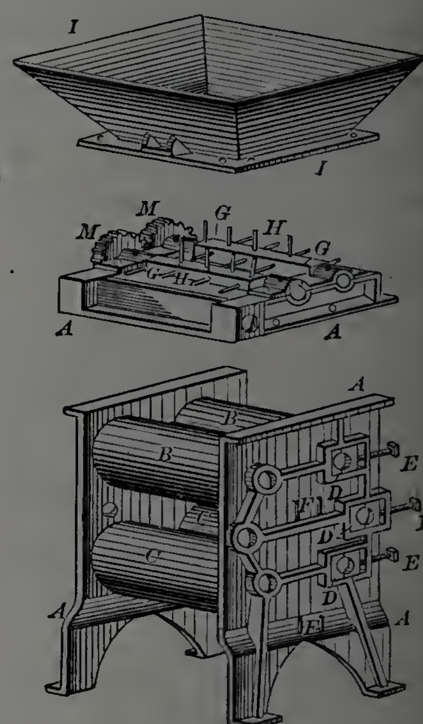


Fig. 103

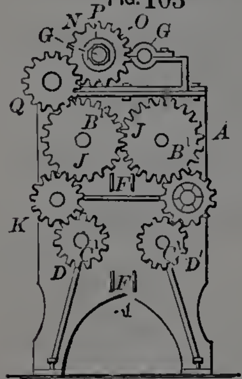
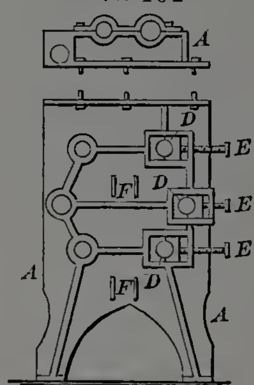


Fig. 104



B, *C C*, the shafts of which are journalled in sliding boxes *D*, latterly adjustable upon the ends of the frame by set-screws *E*, in order that the distance between the rollers of each set may be increased or diminished at will, thus enabling the machine to grind the clay to any required degree of fineness. The upper rollers *B B* are, in practice, adjusted farther apart than the lower ones, and scrapers *F* are located under each roller to remove any adhering clay.

The upper part of the frame is provided with bearings for two square shafts *G G*, provided with spikes *H*, adjusted, as shown, so as to pass between each other when the shafts, which we term the "picker-shafts," revolve. A suitably constructed hopper *I*, to receive the clay fed into the machine, is located on top of the frame.

The shafts B^1 B^1 of the upper crushing-rollers are provided with gear-wheels *J J*, engaging loose or lazy-pinions *K K*, arranged upon the end of the frame, and serving to transmit motion between the shafts of the upper and those C^1, of the lower rollers by means of pinions D^1, arranged upon the latter. The pinions D^1 being smaller than the gear-wheels *J*, it follows that the lower set of crushing-rollers is rotated at greater speed than the upper ones, this being necessary in order to compensate for the greater distance between the latter.

Motion is imparted to the machine from the main drive-shaft by means of a clutch *L*, engaging the shaft of one of the lazy-pinions *K*. By disconnecting the clutch the machine may at any time be stopped.

The picker-shafts *G G* are geared together by pinions *M M* at one of their ends. At the other end, one of the shafts is provided with a pinion *N*, clamped upon it by a pair of collars *O O*, which are tightened by a binding-nut *P*. Motion is transmitted to the picker shaft through the pinion *N* by a loose pinion *Q*, engaging the gear-wheel of one of the upper crushing-rollers.

In operation the clay to be ground is fed into the hopper, when the revolving pickers serve to crush the larger lumps

of clay and any stones or lime, etc., which may be found therein. It then passes down through the frame between the two sets of rollers, the lower ones of which crush it to the requisite fineness.

If any stones should be fed into the machine too large or too hard to be broken by the pickers, the spikes of the latter, when striking against such stone, will catch it and hold it between them. The driving-power will then, through the described arrangement of gear-wheels and pinions, loosen the pinion *N* between the clamping-collars *O O* upon the picker-shaft, thus throwing the latter out of gear without danger of breaking any part of the machine.

The machine is at all times under perfect control, the clutch *L* allowing it to be thrown out of or into gear at any time, as has been stated.

After the fire-clay has been properly reduced or disintegrated and mixed, it is next tempered in a suitable pug-mill, which may be horizontal and have the rollers placed above it, or it can be of upright construction, as shown in Chapter IV., Sec. III., Figs. 3 to 5. The cylinder can be made of iron in one or more parts, and secured to a brick foundation if it is desired to place the bottom on a level with the ground, and the openings for the issuing of clay can be made so as to slip around the cylinder, and by opening them widely, cause the clay to be coarsely ground, and by closing them compel it to be finely ground.

Dies can be placed at the mouths of these mills and large or small drain-pipes formed, which is convenient, especially in small or country yards.

If the pug-mill is arranged horizontally, the clay may be made to issue either from the end or the side of the cylinder, as may be desired.

The moulding may be done either by hand, in a dry or tempered state, or by machinery; but great care is observed not to expose the green bricks to the risk of loss by the weather. The operation of drying is also conducted slowly and carefully under shelter and out of all drafts, which injure the bricks by causing the exterior to dry too rapidly, thereby producing cracks on their surfaces, which lower the grade and value of the stock.

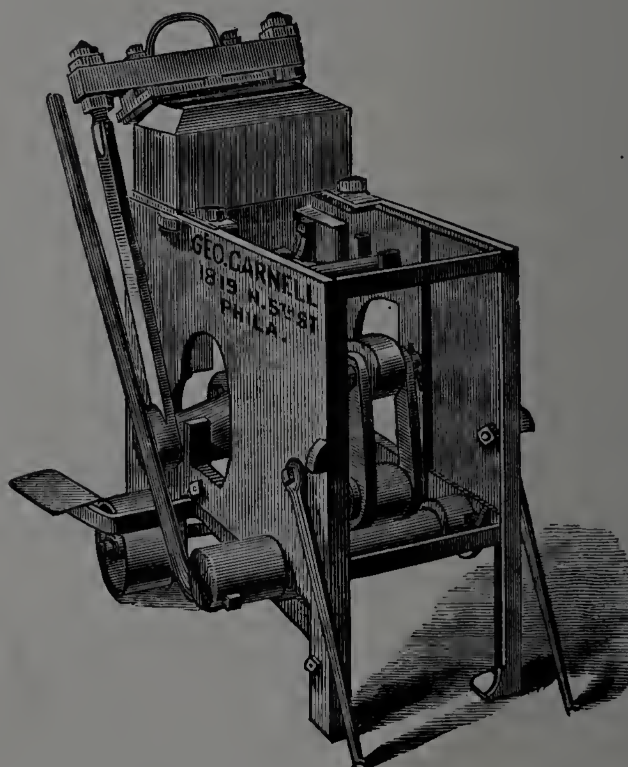
The machine shown on page 201 seems to be well constructed for moulding ordinary fire-bricks, or when strength is requisite, because the materials of which these bricks are usually composed vary greatly in size from an impalpable plastic mass to lumps of cement, biscuit, or silex, three-eighths of an inch in diameter. During the process of tempering and moulding by this machine this conglomerate mass is kept constantly in motion while under pressure; consequently, the smaller particles arrange themselves in the interstices between the larger ones, and the finer particles between them again, and so on, until every crevice is filled and the air excluded; the result of which is to make a dense and homogeneous brick—a result which cannot usually be obtained by pressure without this motion of the particles.

Gerhard's machine, sold by Fairbanks & Co., St. Louis, Mo., is made especially heavy for simultaneously tempering and moulding fire-bricks. It will make 15,000 bricks per day, of ten hours, and is fully guaranteed. The price of the

machine is $750. This machine will make 20,000 bricks per day of ten hours.

Fans should not be used for directly drying any kind of clay products, but they may be employed effectively in all classes of driers to gradually but constantly exhaust the air from the top, thereby at all times stimulating an active circulation among the wares.

Fig. 106.



When the green fire-bricks made from tempered clay are sufficiently hardened to stand the necessary handlings, they are pressed edgewise in a hand-press in which the mould-box is arranged, as shown in Fig. 106, which is for nine inch fire-bricks, and the price on board in Philadelphia, Pa., is $125.

The press shown in Fig. 83, page 225, can also be used for pressing edgewise, and the manufacturers of the machines

shown in Figs. 84 and 86 also make presses suitable for this work.

The care to be observed in drying materials for retorts and crucibles has already been enlarged upon.

The setting of fire-clay products is very carefully done, all stock is gently handled, and when it is in the shape of fire-bricks they are arranged or placed in the kiln in a manner much similar to that employed for common bricks in the same locality in which they are made.

The placing of wares of various shapes in a kiln preparatory to burning is a matter for the exercise of judgment, and requires experience as well as discretion. One piece must be made to securely prop another without having too much of their surfaces in continued contact. Heavy pieces form the base or supports, and the lighter wares are variously distributed, care being observed to allow the steam or "water smoke" every opportunity for freely escaping, and the heat to have regular distribution throughout the entire pile of wares.

If large openings are left one over the other, "flues" will form, and the heat will, during the whole time of burning, quickly rush and circulate among these "flues," thereby causing all the stock exposed in them to be burned unequally, extremely hard on one face and not so much on another.

The loss from cracked and twisted wares caused from careless setting or placing in the kilns is often very large, being much greater in fact than it would be by using extra precaution to avoid "flues" in the setting.

But the "flues" are sometimes, but not so often, formed

from the unequal shrinking of the stock in the kiln, which is an additional reason for having a uniform mixture of the materials.

The circular, domed "over-draft" kilns are largely used for burning fire-bricks and terra-cotta products, and the Hoffman annular kiln is also employed extensively in all parts of the world.

Both of these kilns are so commonly known, that there is no necessity for an explanation of their construction in this volume.

The over-draft kiln shown on page 152 can be used to advantage in the burning of fire-clay wares, as well as for common bricks.

Kilns constructed on regenerative principles are now coming largely into use for the burning of fire-clay products of all descriptions, as it can be performed in them cheaply, thoroughly, and more effectively than in any other class of kilns. They are to the uninitiated complicated; but when fully understood are more simple in their workings than the old styles of kilns.

Mr. James Dunnachie, of the Glenboig Star Fire-clay Works, Lanark, Scotland, has recently perfected an improved regenerative kiln for burning fire-bricks, which has for its object more thoroughly to mix the air and gas burned in such kilns, and to effect a better diffusion of the heat obtained from their combustion, as well as more thoroughly to regulate and equalize the same. These objects are effected by constructing in the walls of adjacent kilns duplex hollow spaces or flues, the alternating portions of the opposite sides

of which have slits or perforations formed therein, so as to enable the heated products of combustion to be passed or discharged from the lowest part of one kiln into the lowest part of the next kiln—that is to say, the kiln which is being heated preparatory to being fired. These flue-spaces are provided with vertical or horizontal dampers, so as to shut off the communication between the kilns, the slits or perforations in the flue-spaces effecting the improved diffusion. In place of forming such flues in the walls of adjacent kilns, flues may be formed in the brick-work outside the wall, in which case the air descends some distance below the floor of the kiln, where it passes through ports, regulated by dampers, into a still lower flue, from which it escapes through slits or perforations formed in the lower part of the walls into the burner or chamber, or opening, wherein it mixes with the gas. For the purpose of admitting either hot air into the upper part of the kilns from an adjacent kiln, or for the purpose of admitting cold air to the upper part of a kiln being fired, a similar flue—that is to say, either duplex or single—is provided with dampers and with slits or perforations in its opposite sides in the walls at or near to the upper part of the kilns. Either hot or cold air is admitted through these upper flues and slits or perforations, when the air admitted at the lower part of the kilns with the gas may be either deficient in quantity to produce complete combustion, or when the temperature of a kiln at its upper part may be either too high or too low. In place of making the flues duplex, with slits or perforations, as before described, they may be made single, with one side—

namely, that through which the discharge takes place—constructed with one, two, or more larger openings in lieu of slits or perforations above or at a level with the bottom of the kiln, and with slits or perforations at the opposite side.

The improvements before described may also be applied to calcining-kilns and other analogous apparatus.

Figs. 107 to 119 represent the invention as applied to kilns arranged in two opposite rows or series of five (less or more) each, the end kiln of each series being connected to the corresponding end kilns of the other series by means of flues; but it may be applied to kilns otherwise arranged.

FIG. 107

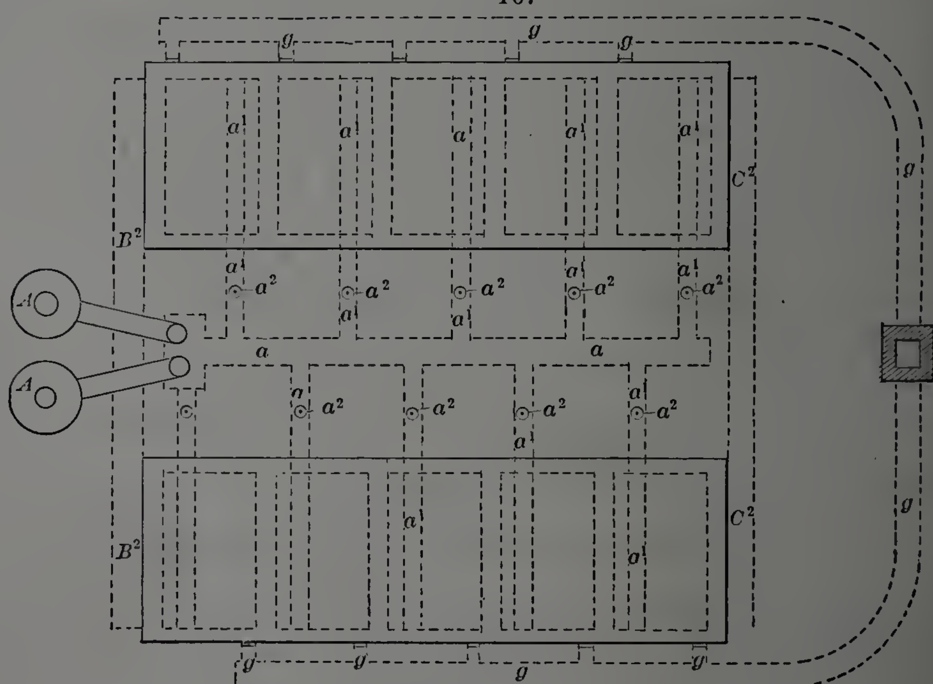


Fig. 107 is a general plan of the series of kilns. Fig. 108 is an end elevation of the same. Fig. 109 is a front elevation of one of the series or rows. Fig. 110 is a longitudinal vertical section of the same. Fig. 111 is a plan of the same,

partly in section, on the line 1 2, Fig. 110. The following figures are drawn to a larger scale, the better to exhibit the flues and passages: Fig. 112 is a longitudinal vertical section of a kiln of the series with portions of the adjacent

FIG. 108

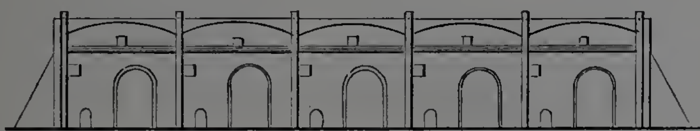


FIG. 109

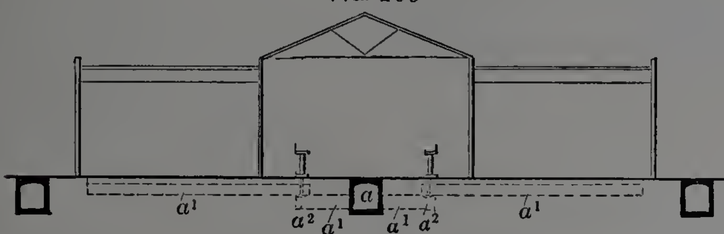


FIG. 110

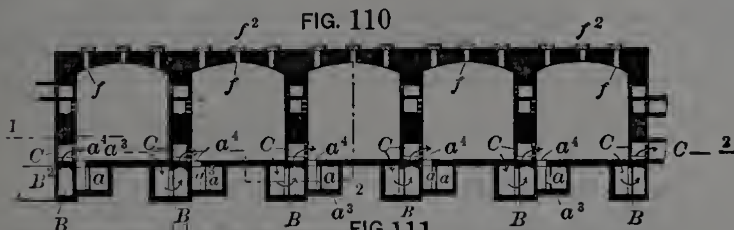
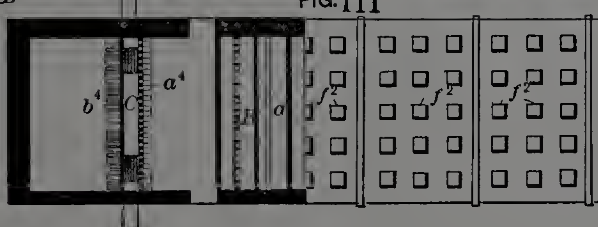


FIG. 111



kilns on either side. Fig. 113 shows one-half of a horizontal section of the same, taken on the lines 3 4, Fig. 112. Fig. 114 is a vertical transverse section on the line 5 6, Fig. 112 showing the side wall of the kiln, indicated by the arrow 7. Fig. 115 is a section on the line 5 8, Fig. 112, but showing the other side wall of the kiln, indicated by the

arrow 9. Figs. 116, 117, 118, and 119 are views of a modification, hereafter more particularly referred to.

The gas to be employed for the burning process is obtained from any convenient source. For example, it is pro-

FIG. 112.

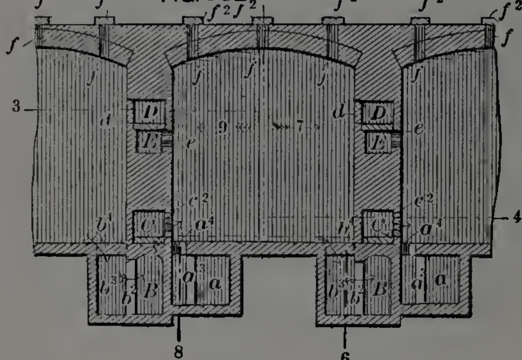


FIG. 114.

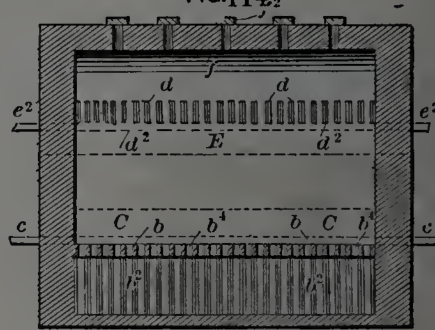


FIG. 113.

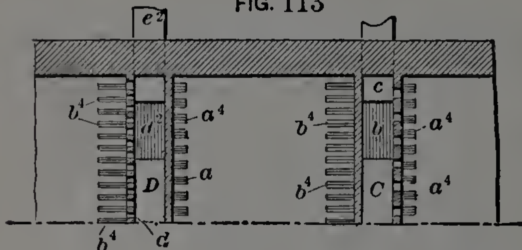


FIG. 115.

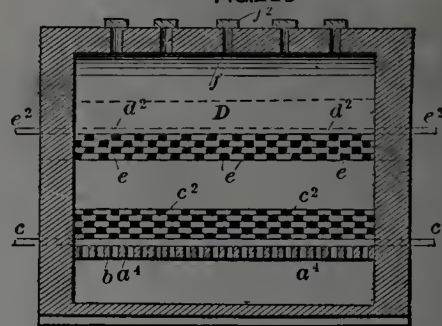


FIG. 116.

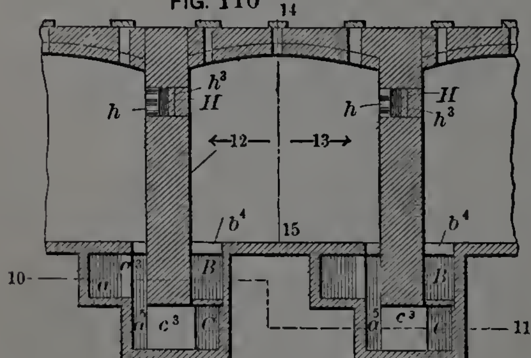


FIG. 118.

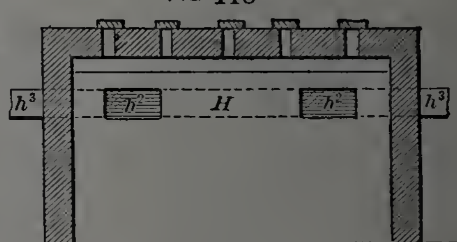


FIG. 117.

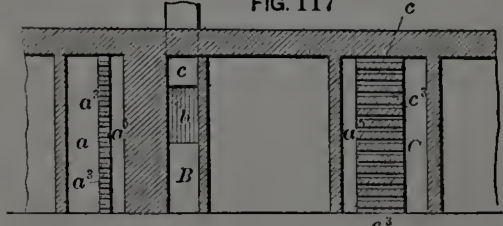
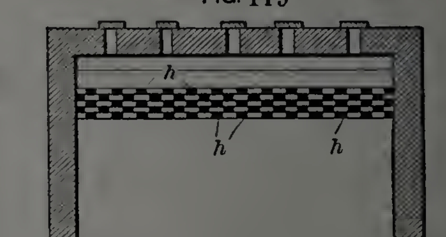


FIG. 119.



duced in gas-producers, indicated at *A*, Fig. 107, and is led therefrom by the main passage *a*, wherefrom lead branch passages a^1 for the gas to each kiln, a valve a^2 being upon each such passage to regulate the supply of gas to each kiln. The gas passes into the kilns by openings a^3 and a^4. In the division-walls which separate the kilns are duplex hollow spaces or flues (marked respectively *B* and *C*) communicating the one with the other by openings *b*, which openings are regulated or closed by dampers *c*. In the side of the flue *C* are passages c^2, opening from the flue just above the outlets for gas a^4 in the one kiln, the flue *B* being in communication by the slots b^2, passage or flue b^3, and slots b^4 with the lower part of the adjacent flue. A duplex passage consisting of flues *D* and *E* is also formed in the upper part of the walls of the kilns, the one passage *D* communicating by means of the openings *d* with the one kiln, and the other passage *E* communicating by means of the openings *e* with the adjacent kiln. The flues *D* and *E* communicate with each other by openings d^2, which can be regulated by dampers e^2. Openings *f* are made in the roofs of the kilns, which openings are covered by slabs or dampers f^2.

In operation, when one kiln is in fire the effluent gases produced therein are passed into the adjacent kiln through the openings b^4, passage b^3, openings b^2, passage *B*, openings *b*, and passage *C* into the adjacent kiln next in the series through the openings c^2, and will heat the contents of the kiln. When the first kiln has been fired off the air passes through that kiln into the adjacent one through the passages *B* and *C*, as before described, issuing thereinto by the

openings c^2. Gas is then turned on to this kiln, and, meeting with hot air, burns and bakes the bricks. The quantity of air passing through the one kiln to be heated on its passage to the adjacent one is regulated by the dampers *c*, and the quantity of gas admitted to this kiln is regulated by the valve *a*. When this last-mentioned kiln is burned off, the supply of gas is turned off therefrom, and this one becomes in its turn the regenerator or heater of air for the next kiln, and so on through the series, the passages marked B^2 and C^2 in Figs. 107 and 108 giving communication between the respective end kilns of each row of kilns. If it is desired to admit hot air to the upper part of any kiln, this may be done by opening the dampers f^2 at the top of a fired-off kiln, and air heated by the kiln thus be caused to pass from the kiln through the openings *d*, passage *D*, openings d^2, and passage *E*, and into the adjacent kiln through the openings *e* to raise the temperature of the upper part of the kiln, or to assist in the combustion of the gas. Where cold air is to be admitted, air passes through the flue *E*, which is open to the atmosphere at both ends. The outlet-passages from each kiln, and the main flues to the chimney into which these passages open, are indicated in Fig. 107, and are there marked *g*.

Figs. 116, 117, 118, and 119 represent views corresponding respectively to Figs. 112, 113, 114, and 115 of a modification of the invention wherein the flues *B* and *C*, for the admission of hot air to mix and burn with the gas, are made in the brick-work outside the kiln-walls in place of in the walls themselves. Fig. 117 is a horizontal half-section on

the line 10, 11, Fig. 116. Figs. 118 and 119 are transverse vertical sections taken on the line 14, 15, Fig. 116, showing the opposite side walls, as indicated respectively by the arrows 12 and 13. The air from the fired-off kiln, and heated thereby, passes down by the openings b^4 into the flue B through openings b (one on each side), regulated by dampers c, into the flue C, and therefrom by the slotted passages c^3 in the lower parts of the kiln-wall into the passage a^5, where it mixes before passing into the kiln with the gas introduced through the gas-passage a and openings a^3.

The flues, either in the lower part or in the upper part of the kilns, may be made single instead of duplex, the one side communicating by a number of openings with the one kiln, and with the other by openings at the ends of this single flue, these openings being regulated and closed by dampers. Single flues of this construction, marked H, are shown in the upper part of the kiln-walls in Figs. 116, 118, and 119. The openings by which the flue communicates with the one kiln are marked h, and the openings at either end of the other side of the flue, to give communication to the other kiln, are marked h^2, their opening being regulated by dampers h^3. A similar arrangement may be applied at the lower part of the wall in place of the duplex flues; but the arrangements of duplex flues shown are preferable.

To give a perfect diffusion of air, it is preferred that where a continuous series of slots is employed for the passage of air into and from the various flues, the slots should break bond or be placed alternately, so that the slots in one side are opposite the slot-divisions in the other.

This invention may also be applied, essentially in the manner described, to calcining-kilns, coke-ovens, or other analogous apparatus.

Fire-clay and terra-cotta clay are sometimes used to form columns, and often for the manufacture of hollow tiles for fire-proofing between iron floor and ceiling joists. When used for these purposes the clay should be fatty and plastic, with an idea to securing the necessary strength for the purposes for which the wares are to be employed.

In the United States Pension Office building now (1884) being constructed in the city of Washington, D. C., all the columns on the principal floor that support the galleries running entirely around the interior of the building, which is four hundred feet long by two hundred feet wide, are made of fire-clay, in separate sections, densely moulded and thoroughly burned. Each section of the column is circular, the thickness six inches and the diameters varying so as to taper from the bottom to the top. In the centre of each block or section there is a small circular hole about three inches in diameter, which allows good action for the heat while the block is in the kiln. The bottom section is carefully bedded in best Portland cement, and encircling it is a light cast-iron rim, forming the base of the column; each section is then laid level in Portland cement, and the hollow spaces in the centre of each block filled with a fine concrete made with Rosendale cement, which does not expand in setting. The surface of the column is then immediately smoothed over with Portland cement, which

is dampened with water once or twice a day, for several days, to prevent the too rapid drying of this slow setting cement.

The best cement for erecting or coating this kind of column is the one given at the end of Sec. I., Chapter VI. There is no danger from saltpetre if the cement is prepared as directed and with clean river sand.

When columns prepared in this way receive proper polychrome treatment, the effect in all classes of buildings is very pleasant, and can be made to form an attractive part of the design.

All medieval buildings were intended to be colored, and the color entered into and formed part of the original design, which in most cases has been lost from the practice of whitewashing them over, which so generally prevailed in the seventeenth and eighteenth centuries. Whenever this whitewash is removed carefully, the original coloring appears; but unfortunately, in getting off the whitewash, the original thin coat of fine plaster which formed the *gesso* or ground to paint upon, is removed in company with it.

In some instances the stone itself seems to have been painted upon, and the color mixed with wax varnish, which is impervious to moisture; and although these have been treated to repeated coats of the worse than senselessly applied whitewash, the coloring still reappears, seemingly in defiance of the ignorance which ordered its application.

At times the coloring was executed while the plaster was wet, in what is termed fresco painting, and thus became part of the plaster itself, and can be destroyed only by the destruction of the plastering.

As the style of carved ornaments changed, so did the style of coloring follow in company with it.

This may seem an out-of-the-way place to inject observations on the matter of artistic coloring, but as it is peculiarly applicable to the decoration of fire-clay columns and ceilings, liberty has been taken to sandwich it between these fire-clay productions, which are generally used only in such class of constructions as receive an artistic finish of this character.

Hollow tiles made of fire-clay are largely employed in fire-proof construction for arches between floors, ceilings, and rafters; the pieces are so moulded as to form a perfectly keyed arch, and so laid as to break bonds or joints, when in place.

They are much lighter than the brick arch and the usual mass of material used to weight the hause or haunch.

In order to give the plastering perfect hold, the ceiling face is roughly scratched before burning. With these tiles a level floor or ceiling can be obtained without furring or lathing; extra thickness of floors and consequent additional height of the building can also be saved. When made porous they absorb all dampness, which is carried off through the hollow spaces in the tile.

Hollow tiles can be used both for heating and for ventilating purposes; flues, ducts, chambers, etc., have been largely constructed with them in many of the United States Government buildings; and are now (1884) being largely employed in the reconstruction of the United States Patent Office building in Washington, D. C. The building was partially destroyed by fire September 24, 1877, since which time these tiles have been used for arches and sometimes for portions

in the reconstruction of the destroyed parts, and Congress has since ordered the remaining portions not touched by the flames to be taken out and made fire-proof, which is now being done.

These tiles have great elasticity to resist sudden impact, and an eight-inch tile arch with a span of five feet between beams will sustain, without deflection, more than 2000 pounds to the superficial foot of floor.

Some recent tests instituted by Gen. M. C. Meigs, now superintending the construction of the U. S. Pension Office building in Washington, as to the resistance of terra-cotta sheathing tiles to dead weight superimposed upon their surfaces, are of interest to builders in all sections of the country, and particularly so to those desiring a cool, non-conducting material for roofing and flooring. The tiles used in the Pension Office are to be covered with an external tunic of metal-roofing, in order to protect them. They are of ordinary pattern, with three rectangular holes running longitudinally through them from end to end, thus insuring dryness, lightness, and atmospheric circulation. The dead weight was applied to the middle of the tiles that were tested, the edges being so supported as to leave a clear span of 22 inches. Tiles of pure clay sustained a weight of 2394 pounds before yielding, while those of mixed clay and sawdust gave way under a dead pressure of 1940 pounds—a resistance amply sufficient for the practical purposes of flooring material, to say nothing of roofing in either case. Indeed, the fire-proof flooring of the new Columbia College Law School—one of

the most elegant Gothic structures erected in New York during the last five years—is composed of tiles of the kind tested by Gen. Meigs, protected at the surface by a tesselated fabric of colored marbles. The tiles are all perforated longitudinally, thus adding to the ventilation resources of the building and obviating the dampness that seems to be unavoidable in floors of common brick, while at the same time securing a degree of resistance to heat that can hardly be predicted of ordinary brick and cement. The use of sawdust, one-third woody *débris* to two-thirds of clay, it appears, renders the tiles considerably lighter and more elastic, without to a sufficient degree impairing their availability for roofing or even for flooring, providing the protection from sharp percussion is adequate to the purpose; and the coolness of such roofs and floors in the hottest days in summer has also been verified by experience in several buildings in New York City.

The tiles which were tested as above stated were made by the Potomac Terra-Cotta Company of Washington, D. C.

Fig. 120 shows three views of hollow tile fire-proof floors; the first is a 6-inch form, between 6-inch light I beams, span 4 feet, concrete 2 inches thick on which is a tile floor.

The second is an 8-inch tile arch, between 10½-inch I beams, span 5 feet, 2 x 4, furring strips are shown bedded in the concrete in case board floors should be desired.

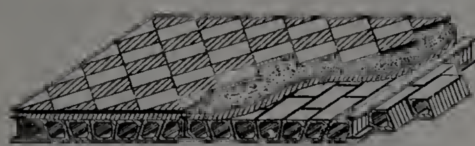
The third view represents a 12½-inch arch laid between 15-inch I beams, ready for either marble, tile, wood, or cement floor finish.

If uniformity in design is essential, the hollow tiles can

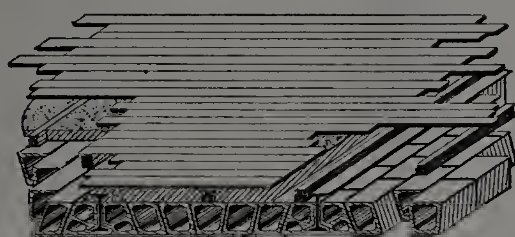
be made to form an arch with concave soffit, as shown in Fig. 121, the ceiling in which presents the same appearance as an ordinary brick arch.

Fig. 120.

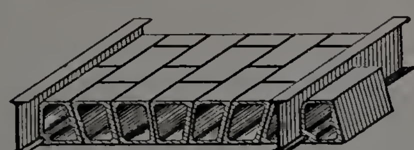
HOLLOW TILE FIREPROOF FLOORS.



View of 6 in. Tile Arch, between 6 in. I beams.
Weight, 30 lbs. per square ft.



View of 9 in. Tile Arch, between 10 1-2 in. I beams.
Weight 38 lbs. per square ft.



View of 12 1-2 in. Tile Arch, between 15 in. I beams.
Weignt, 45 lbs. per square ft.

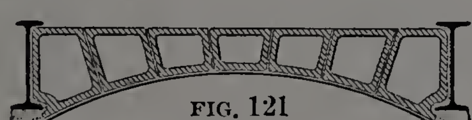


FIG. 121

Section through Hollow Tile Floor Arch
with Concave Soffit.

This class of construction possesses good fire-proof qualities, is economical in space and weight, as well as reasonable in cost, and it can be safely used in all arches of moderate span, where bricks can be employed alone for fire-proof purposes, and in many places where bricks cannot be so used, without requiring large space and much needless expense.

Hollow tiles as well as solid may also be applied to fire-proofing iron and other columns, the disastrous collapses of

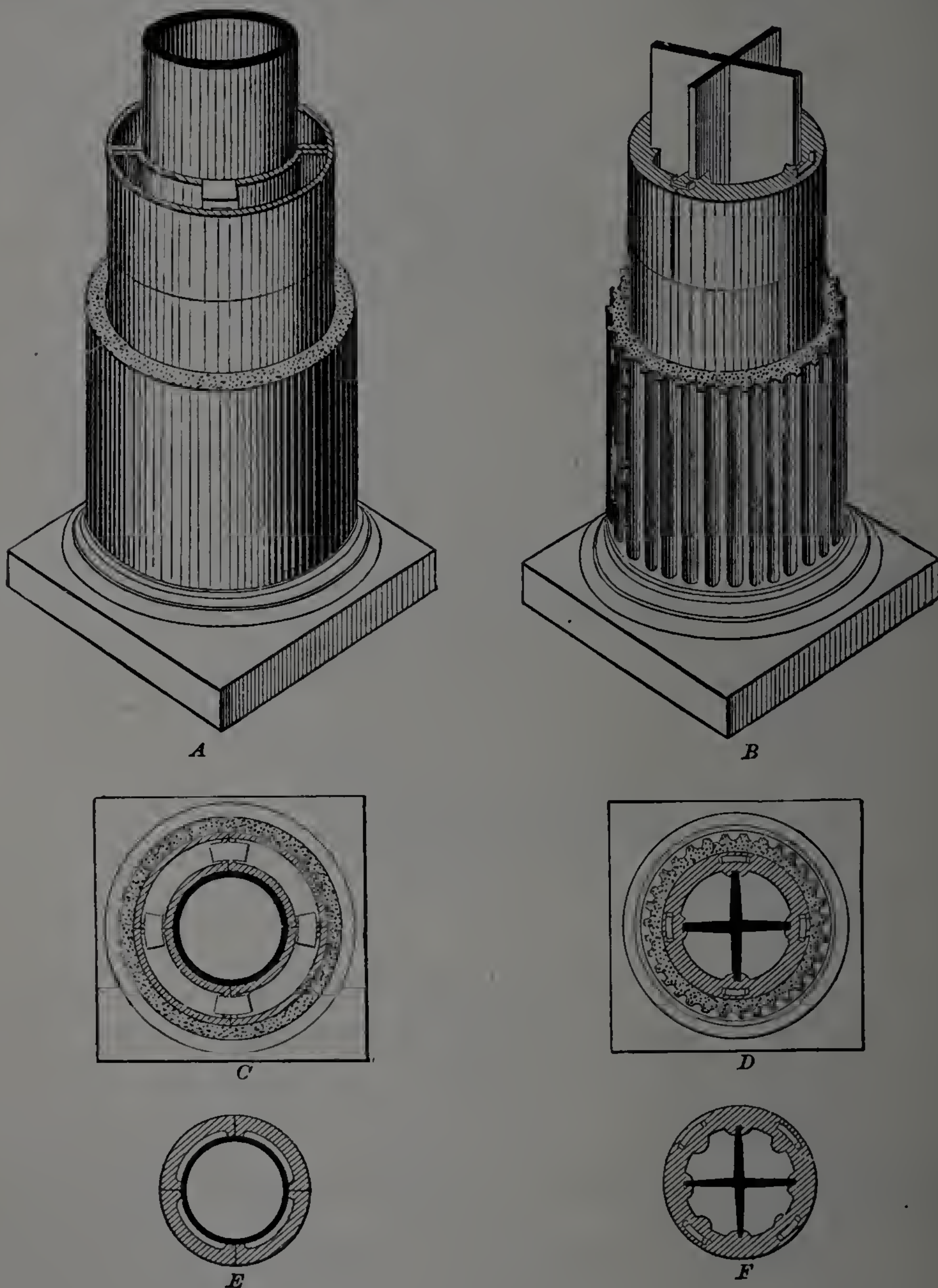


Fig. 122

unprotected cast-iron supports during great fires being what has demonstrated the great necessity for a non-conducting material to protect them when they are employed.

In Fig. 122 *A* and *B* are perspective views of encased iron columns, one a cylindrical and the other an **X**-shaped support.

The first is covered with $2\frac{1}{2}$-inch hollow tile, laid in cement mortar, and firmly tied around all sides of the column with tile clamps; the air space in the tile being a great help during the heat of a conflagration. The **X**-shaped column is encased with a solid tile, a sectoral air space being secured between the column and tile.

In this case the tile does not project so far beyond the face of the column, which allows the proportions to be more properly observed, and besides it is cheaper and just as effective.

The tiles are laid so as to break the bond or joints, and are entirely self-supporting, no drilling or tapping of the column being required.

The cut also shows the usual ways in which the columns are finished after the covering is in place, Portland, Keen's, or Parian cement being the ones usually employed. Sectional plans of the encased columns are shown at *C* and *D*. Sectional views of *E* and *F* show variations in the form of fire-proof casings.

NOTE.—For a portion of the matter contained in this chapter, relating to English fire-clays, the author desires to acknowledge his indebtedness to an excellent article on the subject in the Encyclopædia Britannica, 9th edition, vol. ix. p. 238.

CHAPTER VII.

TERRA-COTTA.

Section I. General Remarks.

Terra-cotta is but another name for architectural enrichments of brick-work of various designs and shapes. The term is of Italian derivation, and, literally translated, means cooked or baked clay. This term was more appropriate to the ancient terra-cotta, which was usually less burned, not so homogeneous and coarser in texture than with us, but that is not a true description of the process as now employed in converting the artistically moulded clay into finished terra-cotta.

From the definition, cooked or baked clay, it might be supposed that terra-cotta did not receive so great a degree of heat as is applied to bricks during the process of burning; but this is not true, as terra-cotta requires a greater degree and a more regular distribution of heat during the firing than are either given or generally required for bricks.

The reason for this is that less lime and alkaline fluxes are contained in terra-cotta clays than in brick-clays, and the former being stronger and more refractory, naturally require greater heat to compel them to part with the water chemically combined with them.

Terra-cotta was largely used for architectural decorations

in Greece, Etruria, Pompeii, Rome, and Mediæval Italy, and it was in the clay plains of North Italy that terra-cotta was first predominantly employed over other materials in architectural construction and ornamentation, and the inspiration of modern designs in architectural terra-cotta is largely drawn from these works, especially those structures erected from the middle of the thirteenth until the commencement of the sixteenth century.

In England, the friezes, cornices, and other highly ornamental work in terra-cotta of the Manor House at East Barsham and the Parsonage House at Great Snoring, both in Norfolk, erected during the reign of Henry VIII., are worthy of particular notice, and the use of terra-cotta for decorative panels and bas-reliefs appears to have been popular during his time.

The gateway of York Palace, Whitehall, designed by Holbein, was decorated with four circular terra-cotta panels, which are still preserved at Hatfield Peveril, Hants.

The gateway of the Rectory of Hadleigh Church, Suffolk, erected at the close of the fifteenth century, was very carefully restored about thirty-five years ago, the terra-cotta for the purpose being creditably reproduced, at the Lyham Kilns, near Hadleigh.

From the latter part of the fifteenth century until after the reign of Elizabeth, terra-cotta was used only in large and expensive buildings; but at the beginning of the eighteenth century the use of terra-cotta was by no means uncommon in Great Britain; but soon after the reign of Queen Anne its use was discontinued. Its modern employment is but a

revived taste, and is the result of laudable efforts, on the part of a few architects, to secure lasting and honest ornamentation in lieu of that sham and dishonest effect procured through the employment of stucco and galvanized sheet-iron, the latter material not being so common in Europe as in this country.

Some of the coats-of-arms seen over many of the shops in London are made of terra-cotta, and in those having been properly vitrified in burning the form is still good, and the exposure to the elements, often for more than a century, has in no way affected the lines.

Many early productions, even of less durability than those now made, are found in ruins of stone, in which the latter material has been steadily disintegrating for thousands of years; but leaving the terra-cotta as perfect in many cases as if recently produced.

In faithfully made and vitrified terra-cotta, we have the great and only lasting triumph of man over natural productions; for timber will rot, stone, even granite, will disintegrate, iron will oxidize, these and all other metals will succumb to the action of fire, and other destroying influences of the elements; but properly made and thoroughly burned terra-cotta will pass through the centuries, and be the last to yield to those influences to which all natural productions must give way, the material being not only absolutely fire-proof, but also in all architectural employments practically time-proof and indestructible.

Bank-notes, notes of hand, deeds of property, private transactions, public records, and many things of this charac-

ter have been and can still be found in a good state of preservation among the ruins of the great city, ancient Babylon; but they are not in the shape of perishable paper or parchment, but in the indestructible terra-cotta.

The best history of Chaldea comes to us in this shape, there is something in these tablets of clay that we have no desire to discredit; they seem to appeal to our practical understanding, and the tendency to doubt them is not so strong as with some modern written histories.

I cannot pay a more eloquent tribute to terra-cotta than by making a free translation from a few sentences of the French of Jacquemart:—

"In the grandeur of the expiring Roman Empire, when the people were wrapped in fine silk and purple, and when to their sandals they were covered with rich embroidery, pearls, and other precious stones, even when vessels of gold, jasper, sardonyx, and onyx had superseded the earthen pottery for ornaments of the temples and with the powerful, and there was symmetry in every line of the commonest form employed in architecture, when golden-grounded mosaics illumined the domes, and the rich columns were formed of many colored spirals, and when magnificent veils of most costly silk were spread before the altar, then the humble terra-cotta introduced itself among all this splendor.

"The bold cupolas, which the eye hesitates to measure under their dazzling images, which, if constructed of stone, would have sunk of their own weight; these cupolas owe their existence still, to excite our admiration, to the judicious employment of terra-cotta in hollow form. The ceramic art

was drawn upon in a way not usually employed, and the ingenious masonry of these masterpieces of architecture was formed by kinds of truncated bottles, strung one into the other, and disposed in parallel curves.

"Other branches of pottery, excepting brick-making, had so entirely disappeared as to leave us no mark of their having been employed at all; but in the expiring civilization of the period, a grand and noble part is bequeathed to terra-cotta to perform in the often exacting positions of architecture, and help perpetuate the achievements of man to the far distant coming ages."

Many buildings of recent construction in England and Germany, as well as in this country, have been effectively enriched through the judicious employment of terra-cotta.

In England, the South Kensington Museum, the Charing Cross railway station and hotel, the Dulwich College and the great Albert Hall, and in this country the United States Pension Office building at Washington, D. C., and many other recent buildings in the cities of New York, Philadelphia, and Boston, are all admirable examples, the architectural effect produced by the blending of brick-work and terra-cotta being generally both harmonious and attractive.

The matter of designs and the manner of treating terra-cotta are subjects for much thought, and require not only artistic ideas, but the exercise of good judgment. Taste and expression are necessary, but this must not be accomplished at the cost of giving or conveying a sense of weakness.

Good construction, next utility, and last decoration are the

order in which the design should be carried out. The last requires an artist thoroughly versed not only in form and proportion, but who is inventive, in order to make the ornament harmonize with the purpose of the object and also decorative in the place it is to occupy.

For special designs of this character the project of offering premiums has been found to work well, as it stimulates ambition, and thus develops the best ideas.

The plan is worthy of a more extensive trial than it has yet received in this country, as we owe our progress in the production of architectural terra-cotta to this date almost alone to the private designs of architects.

Truth is an absolute necessity in all terra-cotta designs, and as a desire for real in the place of sham materials is the cause of its revived use, why should the object of its employment be defeated?

It is not considered an honest treatment of material to make painted and sanded wood take upon itself the appearance of stone, and when terra-cotta is made in imitation of that material and for the purposes of deception it is equally an error, and the responsibility for it should rest as heavily upon the architect who allows it as upon the manufacturer.

All colors that naturally result from the mixtures and combinations of the clays are allowable, but there should be no effort to imitate other substances, as one of the greatest pleasures which arise from the use of terra-cotta in archi-ture, is the satisfaction engendered by the simple merit of the material.

Terra-cotta is now largely employed in all countries, in

the shape of thin plates of burned clay, as a roof covering. In Great Britain and in this country there are usually but three kinds of tiles in ordinary use, plain, pointed, and pan-tiles; the former of these, which are the ones in common use, are flat on the surface; the second are the same as the first, with the exception that the exposed end is either rounded or pointed; the pan-tiles are raised and curved on the surface, so that when laid on the roof each tile overlaps the edge of the next to it, and protects the joint from the wet.

The Romans used flat marble tiles turned up at the edges, with a row of semi-cylindrical ones over the point to protect them.

In the Middle Ages roofing tiles were very extensively employed in England for buildings of moderate cost; but for those of an expensive character they were always considered as an inferior material to lead. It does not appear that any but flat, plain tiles, with such others as were requisite for the ridges, hips, and valleys, were used. The ridge-tiles or crests, formerly also called roof-tiles, were sometimes made ornamental, with a row of embellishments resembling small battlements or Tudor-flowers on the top and glazed, and still are occasionally so treated, but in general they are quite plain.

When the ridge of the roof was covered with lead, these ornaments were formed of that material, as at Exeter Cathedral.

The finials of gables and pinnacles are also in architectural writing sometimes called crests.

With us the crestings as well as finials are manufactured in terra-cotta in a variety of designs and of different heights; but the cresting is usually one foot long, has lap joints and is interchangeable; the cost of the latter is usually from forty to fifty cents per lineal foot, and the finials from two dollars and fifty cents per lineal foot for the plain ones, to fifteen dollars per lineal foot for the larger and for those of a grotesque design.

Terra-cotta crestings, besides being used with tile, are also sometimes employed for slate and other pitched roofs, the rebating of the joints making them water-tight.

In earlier times it was not unusual to employ terra-cotta tiles to form the backs of fireplaces, and in such situations they are sometimes laid in herring-bone courses, as in the great hall, Kenilworth. Most of the fireplaces in Bodiam Castle, Sussex, are constructed in this manner, and the oven by the side of the larger fireplace in the hall is also built of tiles.

The custom in houses was to have a brazier in the centre of the hall and the smoke to escape through the louvre or ventilator at the top; in the other chambers fireplaces were introduced. In the thirteenth and fourteenth centuries fireplaces were somewhat plain, the ornamentation being chiefly the carved corbel on either side of the projecting hood. In the Perpendicular style the system of panelling having been introduced, this was applied profusely to the ornamentation of the fireplace or *cheminé.*

The term chimney was not originally confined to the shaft of the chimney, but included also the fireplace.

There is no evidence of the use of the chimney shafts in England prior to the twelfth century. In the part of Rochester Castle, which is probably of the date 1130, there are complete fireplaces with semicircular backs, and a shaft in each jamb supporting a semicircular arch over the opening, which is enriched with the zigzag moulding. Some of these project slightly from the wall; the flues, however, extend only a few feet up the side of the wall, and then turn out of the back, the openings being small oblong holes.

But a few years afterwards the flues were carried up through the entire height of the wall, which was a most decided improvement over the old way.

The early shafts were circular and of great height; but later they took a great variety of forms, and during the fourteenth century they were not uncommonly very short. Previous to the sixteenth century the shafts were often short, and not unfrequently terminated by a spire or pinnacle, usually of rather low proportions, having outlets of different forms under and sometimes in them, for the escape of the smoke.

There were also taller shafts of various forms, square, octangular, or circular, surmounted with a cornice, forming a sort of capital, the smoke issuing from the top. In the fifteenth century the most common form of chimney-shafts was octangular, though they were at times square; the smoke issuing from the top, unless, as was sometimes the case, they terminated in a spire.

Clustered chimney-shafts did not appear until towards the close of the fifteenth century; afterwards they became very

common, and were frequently very highly ornamented, especially when of brick.

The ease and economy with which terra-cotta can be moulded into ornamental designs for mantels or finishings for fireplaces, as well as for finishings for chimney-shafts, have stimulated the production of a great variety of designs for these purposes, and especially for the latter.

The chimney-caps produced in terra-cotta are of all suitable shapes and sizes; they are made with open as well as with protected tops; the stereotype designs are often good; but they just as often show a great poverty of ideas as regards proportion and ornamentation of the parts. The designs for chimney-shaft finishings vary from a small cap, with a low base and small bevelled chamfer at the bottom, and a light astragal moulding encircling the upper portion and dividing the plain surface, to those in which the parts are of different shapes, variously proportioned and moulded, ornamented in bas-relief, and the top terminating in a gable roof ornamented with crockets and finial. In many of these ornamental chimney-caps all the known, and some of the undiscovered, stages of Gothic architecture are brought out in unhappy confusion.

In some of the simpler ones the designs are much more correct in form and ornament; the prices usually vary from one dollar to forty dollars each, for these caps.

In the handling and rehandling of terra-cotta of all kinds it is liable to be chipped or broken, especially on the corners where it is to be joined to some other piece of the architectural design.

When this happens it is best to examine the broken part, and if it has a slant outward or inward take a sharp chisel and light hammer and make saw-teeth indentures in the sharp part of the break, and then when it is in position point up the place with a cement composed as follows, which will produce a cement which will gradually indurate to a stony consistency:—

Mix 20 parts clean river sand, 2 litharge, and 1 of quick-lime, into a thin putty with linseed oil; if for red terra-cotta, color to the desired shade with Venetian red; if buff, with yellow ochre; if brown, with Spanish brown. The cement should be made all at one time, and the pointing up should also be so done as to avoid a variety of shades. When this kind of cement is applied to mend broken pieces of terra-cotta, or to mend broken pieces of stone, as platforms or exterior or interior steps, it acquires after some time a stony hardness.

A similar composition has been much used to coat over brick walls, under the name of "mastic."

As a safe rule, all classes of building material should be faithfully inspected before being used, and to this terra-cotta is no exception; the point of any steel instrument is a simple test of the texture of terra-cotta; it should not penetrate the surface, and if the point should strike fire through contact the ware is all the better. A sharp metallic, bell-like ring and a clean, close fracture are good proof of homogeneousness, compactness, and strength. Precision of the forms is to the highest degree essential, and can result only from

homogeneous material and a thorough and experienced knowledge of firing.

The material can in many positions be ornamented by judiciously inlaying it with majolica and other tiles.

The modern employments for terra-cotta, architecturally, are for altars, balusters, baptismal fonts, bases of columns and pilasters, belt courses, capitals, chimney tops, columns, consoles, copings, cornices, crestings, finials, friezes, foils, keys, ventilators, medallions, mouldings, newels, niches, panels, pediments, pedestals, pilasters, skew-backs, or springers for arches, spandrels, statues, string courses, tiles, tympanums, vignettes, window heads, window mullions, and tracery.

Terra-cotta can also be employed for brackets, especially when intended to support a statue, corbels, gargoyles, oriel windows, and for interior uses for centre-pieces for ceiling lights, mantels, hearth slabs, and in fire-proof buildings for treads and risers of stairways, plinths for architraves of doorways, base-mouldings and base-panels around the bottoms of rooms.

Terra-cotta is also suitable for all kinds of garden decorations, balustrades, basins, bridges, ferndelabras, figures for weather-vane supports, flower-baskets, fountains, garden steps, garden edging, and other horticultural appliances, lamp-posts, lodges, ornamental conservatories, individual seats, settees, summer-houses and statuettes, also for dairies, mural monuments, tazzæ, vases, and window flower inclosures.

Section II. The Manufacture of Terra-cotta.

The manufacture of terra-cotta is an important one in France, and the statues and other objects displayed in the Paris exhibitions have been remarkably fine.

In its manufacture in England an important clay has long been the potter's clay of North Devon and Dorsetshire, the analysis of which, by Weston, being as follows:—

North Devon.

Alumina	29.38
Silica	52.06
Lime	0.43
Magnesia	0.02
Iron oxide	2.37
Potash	2.29
Soda	2.56
Water combined	10.27

Dorsetshire.

Alumina	32.11
Silica	48.99
Lime	0.43
Magnesia	0.22
Iron oxide	2.34
Potash	2.31
Soda	2.33
Water combined	9.63

Each of these clays contains a small amount of alkalies. The clays of the coal measures, technically known as the "fine-clays," are also much esteemed for this purpose.

In the north of England and in Scotland, the purest

lumps of fire-clay, selected by their color and texture, are used by themselves in the production of terra-cotta; but the concerns of Mr. Blashfield, of Stamford, and others near London, produce a body of much better texture by a careful and thorough mixture of clays.

It requires greater care, and is slightly more expensive for labor; but these are small considerations in comparison to the increased compact, homogeneous and better vitrified body which results from using a mixture of clays.

The precise combination of clays varies with the appearance desired for the terra-cotta; sometimes it is a light cream, or a soft buff color; at other times it may be a cherry-red, or a hard brownish-red color.

A partial vitrification of the mass is desirable in the production of terra-cotta, as it enhances the durability of the body, and, in order to achieve this, clays like the Dorsetshire are added, the small amount of alkalies which they contain acting as a flux and fusing the body to a harder consistency.

New Jersey produces a great variety of clays, and the belt of country underlaid by them extends entirely across the State, and, as described by the State geologist, includes an area of three hundred and twenty square miles; while the area within which these deposits have been worked to the present time is only about seventy square miles, the actual openings of the clay beds being only a very small fraction of the last-named area.

The average depth of these clay deposits is more than three hundred and fifty feet, and the order of supersession is shown in the following table:—

		Feet.
1.	Dark colored clay (with beds and laminæ of lignite)	50
2.	Sandy clay, with sand in alternate layers	40
3.	Stoneware clay bed	30
4.	Sand and sandy clay (with lignite)	50
5.	South Amboy fire-clay bed	20
6.	Sandy clay, generally red or yellow	3
7.	Sand or kaolin	10
8.	Feldspar bed	5
9.	Micaceous sand bed	20
10.	Laminated clay and sand	30
11.	Pipe clay (top white)	10
12.	Sand clay, including leaf bed	5
13.	Woodbridge fire-clay	20
14.	Fire sand bed	15
15.	Raritan clay beds: Fire-clay	15
	Raritan clay beds: Sandy clay	4
	Raritan clay beds: Potter's clay	20

These clays are one of the most important elements of the material wealth possessed by the State.

Large quantities of clays are marketed annually for making fire-brick, pottery, terra-cotta ware of all kinds, tiles, retorts, crucibles, facings for wall papers, etc.

The average price per ton is four dollars, and the average aggregate production of fire-clay alone, in its crude state, exceeds one million dollars.

New uses for clay of this character are being developed all the while. The New York Terra-cotta Lumber Company has established large works at Perth Amboy for the manufacture of lumber by mixing resinous sawdust with the wet clay, which is left porous after the burning, by the sawdust being consumed.

The material is thoroughly ground and mixed in a mill, carried to the upper portion of the building by an elevator bucket belt. There it is shovelled into a compressor, through which it passes to the floor below, and is forced through a die into any requisite shape, and remains in that portion of the building for a time, to stiffen. It is then carried to the ground-floor and dried on a brick floor heated by flues running underneath it from a furnace.

It now goes in the form of slabs to the ovens, where it is brought to a great heat, which burns out the sawdust.

This occupies about forty-eight hours, and produces in that period about one hundred and eighty tons of fire-proof lumber.

It is next planed, tongued, grooved, or sawed into any desirable shape, the dust being carried off by a steam blower.

It can be applied to a variety of uses; it is light, bulk for bulk, and may be united like joiners' work or nailed into place like so much wood.

It has been employed very satisfactorily for filters in the waterworks of the Holly system. When immersed in boiling asphalt for a few moments, sufficient bituminous matter is absorbed to resist the action of water, as the asphalt becomes part and parcel of the material and does not flake off when exposed to cold or dampness, as with common brick, solid terra-cotta, or iron.

It is a good insulator, and the cheapness of the material and the ease with which it can be made water-proof may bring it largely into use for underground telegraphy.

In addition to the purposes which have been named, it

can be used for grain and elevator bins, refrigerators, safe and vault linings, fire-proof jackets for iron columns, safety warehouses, shelves and partitions for libraries, under linings for hearths, etc.

In devoting so much space to the description of the New Jersey terra-cotta clays, no slight is intended to the terra-cotta productions of other sections of this country, as the work done by the Boston Terra-cotta Company and the Lake View Terra-Cotta Company, of Chicago, Ill., is of a high character. They seem to take great care in the execution of all architectural terra-cotta, and have produced a large number of designs for private and public buildings in all portions of the country, with credit to themselves and satisfaction to the architects and owners.

In the States of New York, Ohio, and Illinois there are works for the production of this material, which, although now comparatively small, are certain ere long to develop into large manufactories.

In speaking so highly of the terra-cotta clay of New Jersey, I do not mean to be understood that it is suitable for use without any mixtures or other special preparation, as no terra-cotta clay can be so worked with safety; neither should the terra-cotta clay be confounded with fire-clay, the requirements for which are different, but that of this State is also one of the best in this country, or in the world.

The English, Germans, and French are each in our own van in the production of tasteful and artistically finished terra-cotta; but with a superior clay, and a tendency to develop artistic ideas of finish and form, we shall not long be in the rear.

The body of clay which has been described is best developed at Woodbridge and Perth Amboy, and is practically inexhaustible, and although its presence has been known for nearly, if not quite, two centuries, its employment for the production of architectural terra-cotta is of but very recent years.

It is conveniently situated between the large and wealthy cities of New York and Philadelphia, and being contiguous to the seaboard, and in easy communication by rail with all the developing cities of the country, this section should become to us what the Staffordshire district is to England.

The largest terra-cotta works in this country are located at Perth Amboy in New Jersey. Woodbridge and Perth Amboy both owe their prosperity to manufactures of terra-cotta, fire-brick, and tiles, and the traveller journeying westward in New Jersey, from either of these thrifty towns, will find his way skirted by frequent hollows and excavations, stretching irregularly on either hand.

The color of the rich clay, denuded of the soil and often exposed, varies in shade from a light cream-color, almost white, to a soft buff, and sometimes the clay will be of a dark red color, owing to the abundant presence of the oxide of iron, a very light trace of which impregnates all the clay in the circumjacent region.

The red clays containing oxide of iron in abundance are used only when it is desired to give the terra-cotta a deep red brick color, which is sometimes done for friezes, panels, tiles and other architectural requirements.

For a long distance the way between Woodbridge, Perth

Amboy, and New Brunswick is marked by many of the excavations that have been noted, and which are sometimes of great depth. From the bottom of these, winding wagon roads lead through banks of clay in which large gangs of laborers are regularly at work digging material to be used in the production of terra-cotta and fire-brick, and removing that which is unsuitable for these purposes.

The surface of the country is undulating, and it is but thinly settled, and often a heavy growth of birches, maples, and young pines spreads over it, giving no indications of the riches it conceals, for underlying it is one vast bed of terra-cotta clay, which for fineness of texture and plasticity has no equal in the world.

In applying the term plasticity to this clay, I do not mean it in the common acceptance of that term; but in addition to the quality of receiving and giving form, that also of retaining it, not only while it is being moulded, but in that most trying time to all clays, which is the period that it is yielding its chemical water and "going through the sweat."

It may not be generally known that all things made of moulded clay, although they may appear to be perfectly dry when they go into the kiln, again become softer and almost as plastic as they were when first moulded, and it is this stage of burning that is so destructive to form in the production of artistic and architectural terra-cotta. In describing this critical period in burning, I have used the common parlance of the laborers employed about kilns, for two reasons, the first being that there is no technical term applicable to the same condition of things, and the second is that "going through

the sweat" is a most accurate and literal description. Should the adobes or sun-dried bricks of Egypt, which have been exposed to the influences of that moisture-extracting climate for more than three thousand years, be placed in a kiln and burned, the result would be the same, they would "go through the sweat" and become soft and plastic before they were burned into hard bricks.

The mechanical water has been extracted from them, but the chemical water contained in the clay has never been driven out by burning. The adobe before burning could be soaked in water and in a few hours it would be just as plastic as it was when first made, thousands of years ago, but after burning its plasticity is forever lost.

The vitrifying ingredients usually added to the terra-cotta clays are pure white sand, old pottery, and fire-bricks finely pulverized, and clay previously burned, termed "grog;" these are employed in various proportions, sometimes amounting to nearly thirty per cent. of the mass.

The alkaline salts contained in the clays yield an efflorescence, which, acting upon the silicates of the surface, vitrify to a greater degree the exterior of the terra-cotta, and this harder face should remain intact, and under no avoidable circumstances be allowed to be chipped, chiselled, or broken.

Having prepared the mixture of clays and other ingredients, it is reduced to the consistency of flour, the pans in the mills are either stationary or revolving; but the latter are much preferable, as they usually do more and better work.

Subsequently, careful pugging or tempering is necessary, so as to thoroughly incorporate and mix the combination of

clays and added ingredients. Hot water is sometimes used in tempering the mass; but a jet of steam injected into the interior of the clay cylinder, about the centre between top and outlet, during the process of grinding is a great aid to the clay.

A one-half inch pipe will answer in most cases, and the quantity of steam injected can be regulated at some convenient point by a suitable valve.

Moulding.

The clay, after being brought to the desired consistency, is formed in a mould, usually in several parts, the clay being pressed into them by the hand, and as soon as one section is finished another is added, and so the moulding of intricate pieces of terra-cotta progresses.

The making of moulds for terra-cotta, when the design is intricate, is a matter of great nicety, and requires careful fitting of the parts, which is not always easy, from the shrinking of the parts not being the same.

The making of the moulds is generally one of the chief delays in the manufacture of terra-cotta for buildings; these moulds cannot be changed at will, nor can alterations be made in the ornaments as the work proceeds, not only because the moulds cannot be changed, but because the pieces cannot be cut without ruining the design. The first work of the architect, after his plans are accepted, should be the preparation of all the details for the terra-cotta portion, as each piece has its place and no other will fill it in the build-

ing in that position for which it was designed. There can be none of that hurry and hasty preparation of details now so common on both sides of the Atlantic; there must be carefully matured working details for this material, the manner of joining the parts can best be left to the modeller, who can use locked, rebated, or flanged joints, as may be best.

The production of objects in terra-cotta from models and reproduction from casts are chiefly mechanical, but oftentimes call for experience and skill. A great difficulty is often presented in taking many good forms from one plaster cast, as the cast is liable to deteriorate.

There are several ways for overcoming this; but that which was largely employed in reproducing some of the most difficult terra-cotta work in the great Albert Hall and other large works in England, is the best.

In this process the plaster cast is covered with grease or soap, and then protected by a rubber cloth, on the top of which modelling clay is placed to the depth of four or five inches and fully covering the surface of the cast, then against the modelling clay a backing of plaster is built, in two or more parts as may be desired, and makes the backing to the mould.

When sufficiently hard the backing of plaster is removed and the rubber cloth and modelling clay taken out and laid to one side, the backing of plaster being again replaced. There will now be an interval between the face of the model and the plaster wall equal to the thickness of the clay removed, which is filled with liquid gelatine.

After about fourteen hours the impression in gelatine may be removed and placed upon the original backing of plaster; from the gelatine a plaster cast is now taken; from the latter five or six terra-cotta reproductions may be moulded without injury, provided the face of the plaster mould be slightly greased each time, and care be observed in removing the clay.

The great advantage of gelatine is its strict accuracy in reproducing minutely each line of the plaster model; the yielding nature of the material commends it especially for undercut carvings, as it contracts while being drawn from the incision, and upon it being released immediately resumes the perfect accuracy of its shape.

For all stereotype forms of terra-cotta the clay is usually moulded from smoothly finished moulds of iron, brass, or wood.

In addition to thoroughly mixing the clays, it is necessary to so arrange the moulds as to give an equal thickness to all parts of the body of the material, in order to lessen the chances of cracking in drying or warping in the kiln.

Section III. Drying.

When the shaped clay is withdrawn from the mould, it is usually dried by exposure to the sun or air, or near the hot kilns; but none of these methods are proper, as a greater uniformity of drying is absolutely necessary for moulded terra-cotta of all classes.

This is best accomplished by placing the green ware in a room equipped especially for the purpose.

The walls of this building should be of brick, and "daubed;" or, commonly speaking, plastered on the inside with soft mud made from the loamy sand or washings found in gulleys and other places where it has been carried by the water. The "dob" or plastering should be applied to the inside faces of the walls by the hand, and well rubbed into all cracks and openings, the same as is done for a kiln, before placing the ware, preparatory to firing. The walls should be built so as to be about six feet and six inches in height from the surface of the finished floor to the top of the wall-plate, and the roof have a pitch of about thirty-two degrees for a building thirty-two feet in width. At the apex of the roof there should be a combined vertical skylight and ventilator, which should be operated from the outside, by having the sash to swing on pivots placed in the centre, at top and bottom; at the bottom corner of this sash a small piece of hinged iron should be screwed, to which a stout wire should be securely fastened; this wire should pass over a small pulley, and terminate through a long handle of wood at each end of the building, and within a distance of the ground equal to one-half of the diameter of the sash in the ventilator. When the handle touched the ground, the person operating the contrivance would know that all the sashes in the ventilator were opened. If desired, a guide or marks could be made on the end of the building, so as to indicate any degree of opening. The operation of the ventilators on the outside of the building is much better than to have men stumbling around among the half-dried ware. The pulley at the end of the building, from which the wire

would be worked to open the ventilators, should be placed on the roof, at a distance away from the face of the ventilators equal to one-half the diameter of the sash. The pulley at the end, used to close the ventilators, should be placed slightly on the inside of the face line of the sash.

The terra-cotta should, if possible, be dried by a system of steam coils; then, if not, by an arrangement of flues supplied with heat from two furnaces placed in opposite positions, in the same end of the drying-room. The flues from the furnaces should continually travel and return the length of the room; and, finally, the two separate systems of flues should be joined in one flue, by which it should connect with the chimney, placed in the centre of the end of the building opposite the furnaces. In order to save fuel and obtain a larger supply of heat, each of the furnaces should have a large hot air-chamber directly over the fire-box; the separation between the fire-box and hot air-chamber should be a stout piece of boiler iron built in the walls of the furnace; large-sized, cold air-ducts should lead from the exterior to the hot air-chambers. The heat from these chambers could be turned into the flues just described, or by a proper damper and flues be carried to any desired portion of the building. It could also be used to heat a separate system of flues in the centre of the building, and the heat at convenient points be allowed to escape into the room, leaving the flues from the fire-boxes to heat other portions of the building.

The floor of this building should not be in a low or damp position, and good, deep drains should be cut around it, and

strictly maintained in a clean and unobstructed condition at all seasons of the year.

Before the flues are built, a base made of concrete, and not less than four inches in depth, should thoroughly cover every part of the floor of the room.

This concrete should be made of one part good cement, two parts clean, sharp sand, and four parts broken bricks, stone, or refuse terra-cotta if it can be spared; but none of this broken material should be larger than a small hen's egg.

The concrete should be solidly packed with a rammer until water shows on the surface, and then paved with brick.

This base should be put in, whether the building be heated by steam coils or by flues, as it intercepts the natural dampness which is at all times attracted to the surface of the ground by heat, and which would retard the drying of the terra-cotta.

The roof should be covered with tin, and the water under no circumstances whatsoever allowed to drip to the ground, but be caught in gutters at the eaves of the building, and carried through a down spout and tight sewer to a point well away from the building.

The bricks forming the flues should be placed on edge on the top of the pavement, and a space of about one-half inch should be left between the ends. Tiles for the top of the flues should be about one and one-half inch in thickness, six or eight inches in width and seventeen inches and a fraction in length, could be made on the premises, the flues should be about six inches wide.

The tiles forming the tops of the flues, and being also the

floor of the building, should be closely joined and have moist fire-clay worked into them, that is, those which contain the smoke and gases from the furnaces.

If desired, these flues could also be formed of flat terra-cotta pipe wide at the top and narrow at the bottom, and the wide portion be made to form the floor of the building.

Before any ware is placed in this drying-room, the construction of which has been described, a slow fire should be made in the furnaces and gradually increased for two or three days until all the dampness has been driven from the flues and inside of the walls; during this period the ventilators and doors should be fully opened so as to allow the steam to escape as quickly as possible.

If the chimney should be obstinate and inclined not to "draw" at first, a fire should be made in the bottom of it so as to attract the smoke from the furnaces and the air from the flues.

The drying would be better at all times should the ceiling be lathed and covered with one coat of rough plastering.

By using a room constructed as this or some plan having the same object in view, all kinds of ware could be fully dried, it would not be so liable to injury, which often results from hastily removing soft terra-cotta from out of the sun or from about the kilns at the approach of rain; besides, the ware would retain a more accurate form.

In addition to these, and many other advantages, the preliminary stages of burning could be hastened without injury to the ware, and would eventuate in a saving of fully fifteen per cent. in fuel and in the labor of burning, *i. e.*, in the time.

In even moderate-sized works the saving of time in handling and rehandling ware, in burning time and in fuel, in cracked and other shaky ware, would in one season more than pay for a cheaply constructed and furnace-heated drying-room.

The system of steam-coil drying is preferable in many things to any other plan; but probably only large works would care to go to the expense of putting them in.

Both of these plans have been fully tested, and they are not experiments, but successful and accomplished improvements.

The system of steam drying is employed in a brick-yard in Washington, D. C., and through its steam-heated driers there pass every twenty-four hours from eighty-six to ninety thousand bricks, and the bricks are often so soft when they go into the driers, directly from the machine, that they can scarcely be handled and rubbed without finger-marking. But the next day, be it rain or sunshine, the bricks are set in the kiln and successfully burned in less than the usual time. If the same quantity of bricks were dried to an equal degree by the wind, in the same period of time, they would be cracked and so generally shaky that no market could be found for them, but as it is, the stock produced is sound and in demand.

In addition to the advantages which have been named from driers of this kind, there is one other, which may have nothing to do with money gained or lost, but which should be esteemed above all others; it is the satisfaction of knowing that all green stock along with some special design, some

prized effort, is just as safe in these driers as if it were in the kiln and a faithful burner had it in charge.

In all works producing either terra-cotta or brick, in which both the moulding and drying are done in the open air, too much liberty is taken with the weather by all hands. Everybody keeps on working until the rain is close upon him, and oftentimes actually falling, before any effort is made to save the stock that has been made, and then all hands, men and boys, hastily move a part to shelter, and at the same time ruin it. After keeping this up for a while, and getting water-soaked, they stop, and leave the remainder of the stock for the elements to finish, which is what they had best have done with that which they had disfigured, as no unshapely pottery of any kind ought ever to go into a kiln. Nobody is satisfied with it after it is burned, and the first loss in cases of this kind is always the best.

It should be remembered by all persons about works of this class, and at all times, that everything in the shape of moulded clay is extremely perishable stock until it comes safely out of the kiln, and that in any case of threatened danger, the duty of everybody is to save and secure that which has been produced, and that may at any time be exposed to loss.

I have dwelt thus long on the drying and care of unburned terra-cotta, because it is a subject that has much to do with the production of, as well as the profit in this, and in kindred branches of pottery. The drying processes described can be safely conducted every day in the year, if necessary.

SECTION IV. BURNING.

One of the hardest colors to obtain uniformity in the tint, is the elegant buff, and to secure this rich, pleasing color in terra-cotta, requires long burning, and a highly experimental knowledge of firing, as well as a thorough acquaintance with the clay, and its behavior in the kiln.

Coal should not be used in firing light-colored terra-cotta, as, although the usual products of combustion are separate from the ware, sulphurous fuel darkens and tarnishes the surface. Wood should be used in burning light-colored terra-cotta; but for red or darker colored ware, no objection should be urged against the use of coal.

Kilns for burning terra-cotta are generally circular in form, and are expressly built so as to obtain a greater degree and better distribution of heat than can possibly be obtained in an ordinary open brick-kiln. A perspective view of terra-cotta kilns and works is shown in the frontispiece of this volume.

The principle of applying the heat in terra-cotta kilns by the overdraft system is much approved. In these kilns the heat is carried to the top through flues in the walls, and the kiln being covered, and the draft toward the bottom, the heat descends through the ware.

In this class of kilns, the stock is not so liable to crack, break, warp, and twist, as in the Hoffman and other annular constructed kilns.

But the principal gain in the circular overdraft kilns is,

the impartial and equitable distribution of heat, thereby securing a greater uniformity in the color of the terra-cotta, which, in addition to the savings mentioned, makes them very desirable.

The usual time required for burning terra-cotta is from five to seven days, which is dependent upon the condition of the ware when it is set into the kiln, as well as upon the purposes for which it is required.

Section V. Improvement in the Construction of Terra-Cotta Kilns.

The object of the arrangement shown in Figs. 123 to 125 is to modify the construction of the doors of kilns for burning terra-cotta in such a way that the heat will be distributed equally through the door and the other parts, so that all of the kiln will have a uniform temperature.

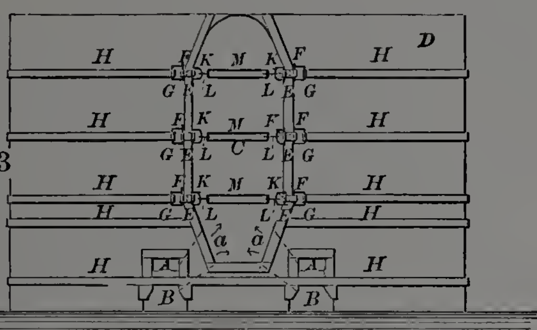
The invention is that of Mr. Alfred Hall, of Perth Amboy, N. J., a gentleman who has spent a lifetime in the manufacture of terra-cotta, and it consists in so arranging a door for terra-cotta kilns, with flues in its inner part, communicating with and forming continuations of the ordinary flues in the kiln-wall, and connected with the furnaces by flues, that a uniform distribution of heat all around the kiln will be effected, and all the articles in the kiln will receive an equal degree of heat, and thereby be burned more satisfactorily than is usual.

Fig. 123 is a front elevation of the improvement, shown as applied to a kiln. Fig. 124 is a sectional plan view of

the forward part of the kiln. Fig. 125 is a sectional elevation of the door.

A represents the furnace-doors, *B* the ash-pits, and *C* the door of the kiln *D*. To the side parts of the door-frame are

FIG. 123



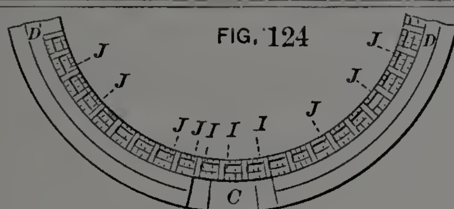
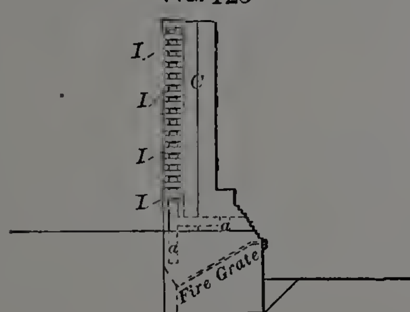


FIG. 124

FIG. 125



attached plates *E*, which project at the sides of the door, and have eyes formed in their outer ends to receive pins *F*. The pins *F* also pass through holes in the ends of the **U** bars or clevises *G*, between which ends the eyes of the plates *E* are placed. The bends of the bars *G* pass also through eyes in the forked ends of the right and left screws *L*. The screws *L* pass through right and left screw-holes in the ends of the bars *M*, which cross the door *C*, and have a longitud-

inal slot formed through them to receive a lever, so that they can be turned to draw the screws *L* inward and firmly clamp the door *C* in place. With this construction the door *C* can be removed by removing the pins *K*, the screws *L*, and the bars *M*.

In the inner part of the door *C* are formed flues *I*, which, when the door is closed, communicate with and form continuations of the ordinary flues *J* in the inner parts of the kiln-walls. With this construction the inner part of the door and the inner wall of the kiln will be heated perfectly, so that there will be no cool part of the kiln, as the products of combustion from the furnaces *A* are introduced into the flues *I* of the door *C* through flues *a* in the same manner as they are introduced into the flues *J* in the inner wall of the kiln, so that the heat will be distributed evenly all around.

CHAPTER VIII.

THE MANUFACTURE OF ROOFING TILES AND SEWER-PIPES.

Section I. General Remarks.

The word tile does not often occur in the Bible; but that tiles were used in very ancient times, not only in buildings, but also for many purposes for which we employ paper, there is not the least doubt, and this is particularly true in regard to Assyria, in which country almost every transaction of a public or private character was first written upon thin tablets of clay, or tiles, and then baked.

The prophet Ezekiel, who was among the captives near the river Chebar in the land of the Chaldeans, is among the first to describe the use to which the tile was sometimes put for receiving drawings or portraying of plans.

In 595 B. C. Ezekiel was commanded to make use of this Assyrian practice at the time when the siege of Jerusalem was prefigured, the commandment being in the following language: "Thou also, son of man, take thee a tile, and lay it before thee, and portray upon it the city, even Jerusalem," Ezekiel iv. 1.

The plan of the siege and all the details were fully explained, and the manner and period in which they were to be carried out were predicted.

From the profuseness with which the Assyrians employed colors in the decoration of bricks and many internal as well as exterior architectural positions, and in their most gorgeously dyed apparels and head-dresses, household furnishings, horse equipments, and in fact in every position that it was possible to attract the eye or please the taste, it is not improbable that when tiles were used for roofing purposes they were also richly colored and ornamented in a great variety of designs, imparting to the roofs a highly ornate appearance.

Rome was originally roofed with shingles, which gave a general invitation to the great and destructive fires which so often occurred; and no effort seems to have been made to lessen the danger from this source until about the time of the war with Pyrrhus, at about which time tiles of burned clay were introduced.

In Knight's "Mechanical Dictionary" we find three good illustrations, with description of the tiles used by the Greeks and Romans, and modifications of the pantile. About the time of Pausanias, 620 B. C., tiles of marble were largely employed in Greece; the temples of Jupiter at Olympus, and of Athenæ at Athens (the Parthenon), were thus covered.

The ancient Greeks always clung to marble; at no time did they show any great desire to employ burned clay in their architectural constructions. Roof tiles of bronze and gilt were used in some cases.

The lower edges of the joint tiles were protected and ornamented by *frontons*, and the edges of the flat tiles were

turned up and covered by semi-cylindrical joint tiles, termed *imbrices.*

Fig. 126 shows a form of marble tiles employed by the Romans, and Fig. 127 the marble tiles sometimes used by the Greeks; they have both been imitated in clay.

Fig. 126.

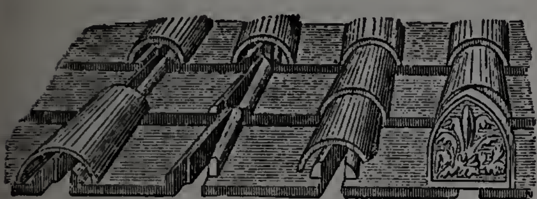


Fig. 127.

In Roman architecture, both flat and round tiles were largely employed; roofs were not uncommonly covered with flat and curved tiles alternating.

The plain tiles now in general use in England weigh about from two to two and one-half pounds each, and expose about one-half their surface to the weather, four hundred of them covering one hundred superficial feet of roof surface; they are sometimes hung upon the sheathing board by two oak pins inserted through holes left by the moulder.

Plain tiles are also now made with grooves and fillets on the edges, so that they can be laid without overlapping the usual distance, the grooves leading the water. This may answer for some cheap constructions where lightness is also a consideration; but the plan is a bad one, as they will certainly leak in the driving rains and drifting snows, and they are also subject to injury by hard frosts.

Pantiles were first used in Flanders, the wavy surface lapping under, and being overlapped by the adjacent tiles. The English pantiles weigh from five to five and one-quarter pounds, expose ten inches to the surface, and one hundred and seventy-five of them cover a square, or one hundred superficial feet of roof surface.

A gutter tile has come into use in England; it forms the lower course, overhangs the lower sheathing board or lath, and is nailed to it.

Sliding tiles are used as substitutes for weather-boarding; holes are made in them during moulding, and they are secured by flat-headed nails to the lath.

The exposed face, called the gauge, is sometimes indented to represent courses of brick; fine lime mortar is introduced between them, when they rest one upon the other.

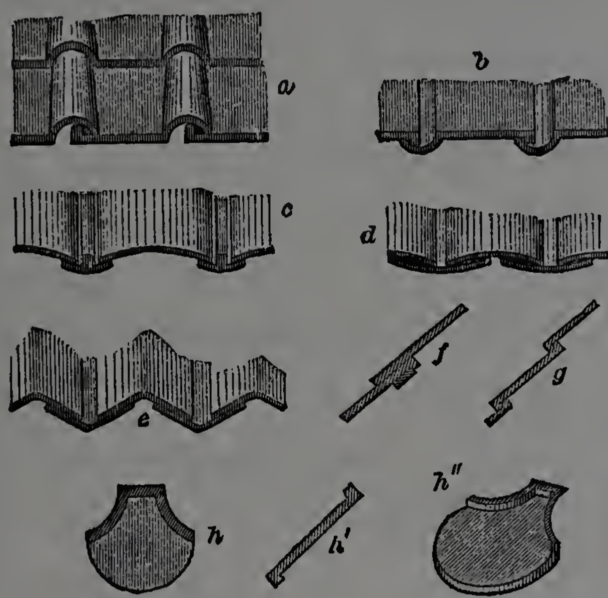
These sliding tiles are sometimes called weather-tiles, and sometimes mathematical-tiles, the names being derived from their exposure or marking. They have a variety of forms, having curved or crenated edges, and are also variously ornamented with raised or encaustic figures.

Modifications of the pantiles are shown in the examples *a b*, Fig. 128, the edges being turned up and down respectively; *c d e* are modifications of the ridge-tiles, in which the gutter and ridge are placed alternately. *f g* show modes of securing; the first is moulded with a lug, which secures itself in position by catching above the lath of the roof; the second shows a tile moulded with two lugs, by which it engages the tiles of the courses above and below.

h h′ h″ are elevation, section, and perspective views of a

tile exposing a semicircular face to the weather. The semicircular portion has a drop flange, which catches over the

Fig. 128.



re-entering curves of the upper part, these curves having upturned flanges for that purpose. Whenever roof tiles are to be glazed, they are varnished after being burned; the glaze is then put on, and the tiles are then placed in a potter's oven and remain until the glaze commences to run. The glaze is usually made from what are called lead ashes, being lead melted and stirred with a ladle till it is reduced to ashes or dross, which is then sifted, and the refuse ground on a stone and resifted. This is mixed with pounded calcined flints.

A glaze of manganese is also sometimes employed, which gives a smoke-brown color.

For a black color iron filings are sometimes used; for green, copper slag; and for blue, smalt is employed, the tile first wetted and the composition laid on from a sieve.

At one time very inferior roof-tiles were made in England on account of the careless weathering or preparation of the clay employed; and in order to cure this a statue of Edward IV. required that all clay for tiles should be dug, or cast up, before the first of November, and not made into tiles before the March following.

The garden of the Louvre in Paris was called the Tuileries, as being a place where tiles were anciently made; a magnificent palace was begun there in 1564 by Catherine de Medicis, wife of Henry II., finished by Henry IV., and splendidly adorned by Louis XIV., but was sadly defaced in our times, during the Franco-Prussian war.

Modern tile-covered roofs add greatly to the picturesque appearance of buildings.

A portion of a roof covered with diamond-shaped tiles is shown in Fig. 129, and the form of the tile is shown in a section, and a plan of face and bed.

Fig. 130 shows a roof covered with tiles of various shapes, and Fig. 131 shows the six forms of roofing tiles in most common use in this country.

A great advantage for the tile roof is that it is a non-conductor, and, therefore, cooler in the summer season than any other kind of roof. The buff tile, being lighter in color, is the coolest, as it does not absorb the rays of the sun. Tiles are also a better protection against lightning than the lightning-rod, as the latter attracts electricity, while the former is a non-conductor. Insulators, made of pottery, are extensively used on telegraph lines in Europe and portions of America.

The rain water collected from a tile roof is much purer

and cleaner than from any other kind of roof, as the tiles are very smooth, and no dust or soot settles upon them.

Fig. 129.

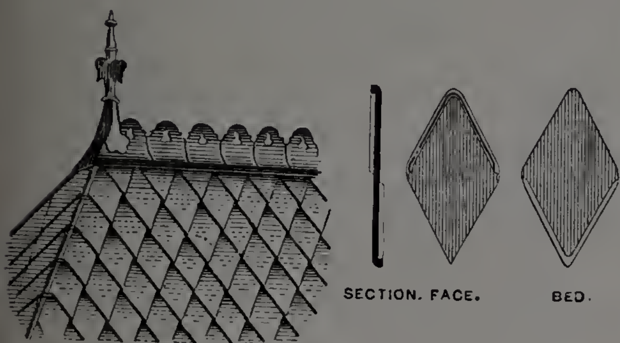
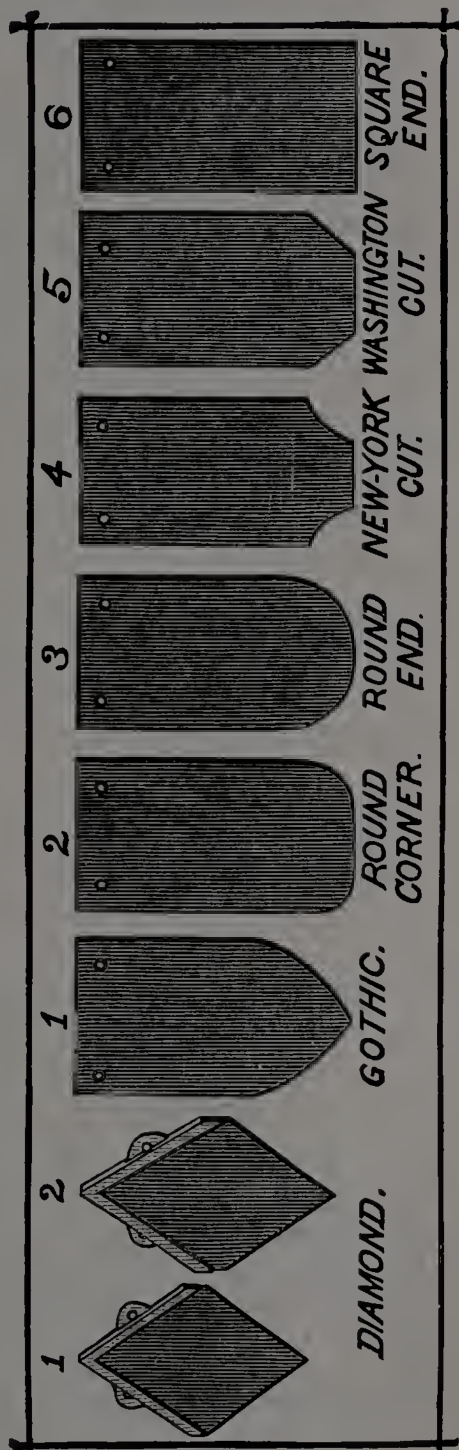


Fig. 130.

Fig. 131.



Tiles are indestructible, and are not affected by heat or cold. They will not crack and slide off the roof, like slate, leaving the sheathing exposed, when subjected to sudden heat, as by the burning of an adjoining building.

After doing service on one structure, the tile can be taken off and used on other buildings. Tiles should not be put upon a roof that has less than one-quarter pitch (a slant of six inches to the foot), although we have seen some roofs of less pitch which are satisfactory. A roof to support tile should be somewhat stronger than for shingles. The rafters should be 2 x 6, 18 inches apart, and well stayed, so that they cannot spread. The sheathing should be of soft wood, of even thickness, and close together. Generally felt or tarred paper is placed under the tile, although it is not necessary to make the roof water-tight, but it stops circulation and makes the roof warmer in winter, and adds but little to the cost.

Section II. The Process of Manufacturing Roofing Tiles.

When the process of manufacturing roofing tiles is conducted by hand, the method is nearly the same in this country as in England, and but few improvements have been made in this mode of production; but by the machine process we are enabled to manufacture very satisfactory roofing tiles at but a small cost.

The clay of which the tiles are made is dug and spread out in shallow beds to disintegrate, and a hot sun or dry frosty weather is best for this.

In all cases the clay should next be finely pulverized by passing through iron rollers or other suitable appliances, and too much care cannot be given to this branch of the preparation of the clay, as has before been observed.

The clay-mills shown in Chapter VI. can be used to advantage in pulverizing the clay.

A good pug-mill which can have the knives made larger at the top than at the bottom and used for tempering the clay when the tiles are made by hand, is shown in Chapter IV.

The usual form of pug-mill employed in England is generally six feet high, three feet in diameter at the larger or upper end, and two feet at the bottom.

The clay is kneaded and completely mixed by a revolving cast-iron spindle, which carries a series of flat steel arms, so arranged as to form by rotation a worm-like motion upon the clay, which is pressed from the larger to the smaller diameter of the tub in which the clay is confined, and finally comes oozing out of an aperture at the bottom; in this manner of tempering great cohesive power is given to the clay.

The clay is then ready to make roofing tiles, the moulding is usually conducted in a shed, and most of the manufacturers prefer to place their tiles in the open air, if the weather allows.

The moulding table or bench is supported on four legs, which are well under the table, leaving the two ends of the top of the table to project liberally. The coal-dust box, 14 x 8 inches, is at the left hand of the moulder, at the corner of the table, and the moulding board, 14 x 10 inches, is usually placed slightly to the right of the coal-dust box.

The mould employed is $12 \times 7\frac{3}{4}$ inches and $\frac{1}{2}$ inch thick, made of oak, and usually plated with iron.

The moulder works a lump of clay by hand into an oblong square, the mould is placed on the bench, and fine coal dust sprinkled over it; the lump of clay is then taken up and thrown into it with force, which is cut off level with the top of the mould by a brass wire, strained upon a wooden bow; the lump of surplus clay is removed, and that in the mould is finished by adding a little clay to it, if necessary, and smoothing the face over with a wooden tool.

The moulded tile is then placed upon a thin board, first sprinkled with fine coal dust, and so the process is repeated, the lump of clay being added to every time six tiles are moulded. The off-bearer carries two tiles at a time, one on his head, and one on his hands, to the floor, where they are allowed to remain for four hours out of doors in fair weather, and then collected and placed together, the nib end changed alternately, so as to hack them closely and squarely.

In this condition they remain for two days, so as to allow them to toughen; the situation of this hacking should be dry, but not hot.

The set or curved form is then given by placing six of the tiles at one time on the top of the horse, which is a three-legged stool, having the top about three-quarters of an inch longer than the tile, the top being a convex curve to a radius of about ten feet and three inches, and having a height of about 2 feet 7 inches from the level of the ground to the top of the block.

The nib end is reversed each time, so as to allow the tiles to lie closely together without injury, and a wooden block lifted on top of the tiles, raised by the projecting ends, and three quick blows given with it on the tiles; this block is concave and curved, so as to correspond with and fit neatly over the upper surface of the horse.

The tiles are then carried away and stacked edge together in the shape of a half diamond, three tiles being used to form each side; two laths are then placed on the top of the first hack of tiles, one lath at each outer edge; another hack of tiles is placed on the laths, so arranged as to form a full diamond with the openings left between the first course of tiles; two laths are then placed in the same way on the top of the second course of tiles, and the third course is then hacked so as to form a full diamond, with the openings left between the second course of tiles.

This is the final drying, and they are then carried to the oven twelve at a time, with the edges of the tiles resting against the breast of the carrier.

Objections to roofing tile, in this country, have heretofore been made to the effect that the tile was heavy, made of coarse clay, poorly burned, that it would absorb a great amount of moisture, so that freezing and thawing would cause it to crumble, and, in appearance, it was anything but handsome. Whatever foundation these objections may have had in the first product of tiles, our manufacturers have now fully met and remedied these drawbacks to their use.

All roof tiles require more careful burning than bricks, and before they are placed in the oven, the bottom is

covered with bricks, so as to take the first flash of the fire, which would destroy a course of tiles in that position from the warping and discoloring.

On the top of this course of bricks about nine thousand tiles are set, which form a square in the heart of the kiln, the space between the tiles and the curved sides of the oven being usually filled with bricks.

The tiles are set edgewise in lots of twelve, called bungs, changing their direction with each lot, being set cross and lengthwise alternately. They are placed in a vertical position, and the nibs of the tiles space them off from each other and support them in a vertical position; the checkered manner in which they are placed in the oven, insuring full action of the fire through the stock.

A uniformity of heat is a great desideratum in burning tiles, and the old form of circular oven, so much employed in Staffordshire, is found to answer the purpose, and do the work more thoroughly than any other in use.

A wall is sometimes built around the oven in order to protect the fires, and prevent one from being urged more than another by the changing direction of the wind.

A sufficient space is left between the wall and the oven to allow the fireman to attend conveniently to his fires; five feet six inches is usually high enough for this wall.

The oven having been filled, the doorway is walled up with bricks and faithfully daubed over with loam and sand, the fires are lighted and kept slowly burning for the first five hours, after which time they are then progressively increased for the next thirty-three hours, making the total

time thirty-eight hours for hard fired tiles, four tons of coal being consumed in the burning. The fireman determines the heat by directing his sight to the mouths and top outlet of the oven; when the heat is reached, and before the fires burn hollow, the mouths are stopped up with ashes to prevent the cold air from cooling the oven too quickly.

These ovens are fired once a week, but can be fired easily three times in two weeks if so desired.

The manufacture of plain roofing tiles can be conducted with a small capital, the process and requirements not being very intricate or expensive.

But to conduct the manufacture of all the tiles required for roofing, and the other articles generally produced in large tileries requires a large capital and a thorough knowledge of the business in all its details.

In all the large tile works all the operations of manufacture are conducted under shelter, and a large variety of articles are produced, of which the following list is but a part:—

Chimney-pots, circulars for setting furnaces, etc., column bricks, for forming columns, drain pipes, drain tiles, fire-bricks, garden-pots, hip tiles, oven tiles, paving tiles, pantiles, plain tiles, ridge tiles, and anything in the line required to order.

With the exception of fire-bricks, the clay used for all these articles is the same; but for circular bricks, column bricks, kiln bricks, oven tiles, paving tiles and paving bricks a certain quantity of loam is mixed with it, which for the oven tiles must be of a very good character.

To faithfully describe the manufacture of all these articles would increase the size of this volume out of all proportion to its design; the principle of procedure is the same in each case, but no two articles are made or finished in a similar way, each requiring different tools and moulds.

The London tileries, which are the largest in the world, pay particular attention to proper preparation of the clay for the particular purpose for which it is to be used; there not being the same haste to get the clay into the kiln that is so often shown by some smaller manufacturers.

The first stage in the London tileries is the weathering, which is about the same as has been described for plain tiles, the object being to open the pores of the clay, separate the particles and thereby compel it to absorb the water more readily in the process of mellowing.

This is accomplished by throwing the clay into pits, covering with water and leaving it to soften or ripen. The clay is now usually passed through the rollers and the stones taken out before it is put into soak, which is a term also used for the mellowing process.

The kilns used for burning the wares produced are usually conical in shape for more than one-half the height, about 40 feet wide at the base, and having a total height of about 25 feet from the bottom of the ash-pit to the top of the dome, which is slightly convex. These kilns are quite expensive to build, eight thousand dollars being about a fair average, fire-bricks being generously employed in the interior; this class of kilns is largely used for burning pantiles.

Before the pantiles are placed in the kiln, one course of burned bricks is laid, herring-bone fashion, one and one-half inches apart over the bottom.

The tiles are then stacked upon this as closely as they can be, one course above the other. The hatchways are bricked up as the body of the kiln is filled. When the top layer is done, it is covered or platted with one course of unburned tiles laid flat; then on the top of these a course of burned pantiles is loosely laid. The hatchways are carefully daubed over, the fires lighted and kept gently burning for twenty-four hours, and then gradually increased, until at the end of six days they are let to die out, the burning being accomplished.

The class of goods which the kiln contains has a great influence upon the quantity of fuel consumed in a burning, chimney-pots, garden pots, etc., not requiring so much as more solid goods.

In this country, the manufacture of roofing-tiles is a comparatively new industry; but it is rapidly growing in public favor, and their employment is becoming quite general.

Many large and costly, as well as small or ordinary dwelling-houses, church buildings, extensive work-shops, barns, etc., are covered with tile roofs.

With us, the tiles are usually of three colors, red, buff, and black. The color of the red tile is produced by the employment of clay containing a large per cent. of oxide of iron; this is sometimes present in the beds with fire-clays, which are the class usually employed for roofing-tiles; at

other times, it is necessary to mix some foreign clay, containing a large per cent. of oxide of iron with the material.

The color is made deeper and more uniform by rubbing the tiles with finely-sifted red moulding sand; this should be done while the tile is quite damp, so as to get the sand to stick or hold to the faces.

The buff-colored tile is made of nearly pure fire-clay, and it is slightly lighter in weight than the red tile.

The black tile is made by washing it over before burning with manganese dissolved in water, which, in the process of burning, is converted into a perfectly durable coating of great hardness.

The patterns usually employed with us for roofing tiles are of several kinds; the large diamond, the small diamond shingle, round corner, round end, gothic, etc., as shown in Fig. 131.

The large diamond tiles are 14 inches, the length of the diamond, and $8\frac{1}{2}$ inches in the width; 250 cover one hundred surface feet, 10 by 10 feet, called a "square," and weigh 650 pounds.

They are fastened with two sixpenny galvanized iron or tinned nails. This kind of tile is used more than the other styles, as it is lighter in weight, and less in cost.

The small diamond, 6 by 10 inches, requires 500 to cover a square, and it weighs 600 pounds. It is nailed with five-penny nails, and is used more especially for towers, porches, dormer windows, and in side panels, for ornamental purposes.

The shingle tiles are the plain flat tiles described in the commencement of this section; they are three-eighths of an

inch thick, have two counter-sunk nail holes, and are made of any size, not exceeding 6 by 12 inches; they can be had for round or square towers, dormer windows, etc., and the points are sometimes cut semicircular, octagonal, gothic, or pointed.

They have been largely used in the Eastern States, and on some expensive buildings for roofing and side ornamentation, as at the State Capitol at Albany, New York, on which building they are wired to iron ribs.

These tiles are generally laid about 5 inches exposed to the weather, which requires about 480 for a square, weight being 1100 pounds.

The pantiles measure 12 inches in length by $6\frac{1}{2}$ inches in width at one end, and $4\frac{1}{2}$ inches at the other, and if they are lapped $3\frac{1}{2}$ inches on the roof, 350 will be required for a square, which will weigh 850 pounds.

This kind of tile makes a strong roof cover, and can be walked upon without danger of breaking, and it is especially suitable for workshops and factories; it is sometimes made with lugs to hang on to ribs, the use of nails being thereby avoided, which are liable to rust away where much bituminous coal is used. It is also made with nail holes, to secure it to the sheathing. Brick-making is now mostly done by machinery, and there is not the least doubt but that tiles of all kinds will also be generally so made both in this country and in Europe.

The roofing tiles which have just been described are made by machinery by the firm of J. C. Ewart & Co., Akron, Ohio.

The machines which they employ were patented by Mr. C. J. Merrill about ten years ago. Mr. Merrill was, until a short time since, a partner of Mr. J. C. Ewart, the firm then being Merrill & Ewart.

In describing this class of machines, I shall be more particular and minute than in the description of brick-machines, as the workings of tile-machines, as well as the manner of their construction, are not generally so well understood.

The successful inventor of labor-saving machinery leads the van of civilization, as man's physical requirements increase; these can be met from this source at an enormous saving of time and labor; machines stimulate business, add increased interest to all pursuits, concentrate the hours of employment, and it is only from this source that the hours of labor which the workingmen of this and other countries are trying to curtail, can be successfully reduced, and all the wants of mankind supplied at the same time.

From the start, workingmen have directed their influence against labor-saving machinery; but in defiance of their efforts against it, good has resulted to them, in spite of themselves. Would they like to go back to the old hours of labor, from sunrise to sunset, live as they did then, and do without the advantages of education to themselves and children, now so common in this country? Cheap homes, food and raiment, as well as cheap books, and other sources of knowledge are the results of labor-saving machinery.

So anxious are the governments of New Zealand and other Australasian colonies, as well as nearly all the governments of South America, for the introduction of tile-machines as

well as brick-machines, that they admit this class of machinery free of duty, and in some of the exhibitions in those countries they have even paid a large part of the cost of their transportation from this country and from England, and our inventors can with profit push their contrivances of this character in those countries as well as in Mexico.

The Merrill roofing tile-machine shown in Figs. 132 to 143 is a valuable invention, and the tiles which it has produced cover many roofs of private and public buildings in all parts of this country.

The practical operation of the machine is as follows: The wheels are made to revolve in direction of the arrows; a certain portion of clay is placed in the dies, which by the corresponding curvature of their faces, when the dies begin to move, press the clay at one corner or end by a rolling motion, thereby packing the clay into all parts of the dies, and forcing the surplus clay out at the opposite corner. While the clay is thus being pressed the nail-holes are punched, the punches being forced out by the head or bar coming in contact at the proper time with cam *A*, Fig. 132, indicated by the dotted lines, attached to the inside of the standards, one on each side of the wheel, over which the projecting ends of the head slide, thereby forcing out the punches into the dies, and perforating the clay. The moment that the holes are punched the punches are withdrawn into the wheel by the springs. At this time the tongue at the bottom of the lower die is forced out by the projecting ends of the head *H* coming in contact with the side cams *B*, Fig. 132, thereby forcing outward the rod *d*, which so far

pushes out the tongue as to allow the end of the tile thereon to fall upon the endless apron *N*, Fig. 132, whereby it is moved away. The use of the steam in connection with the dies is to heat them so as to relieve the clay after the tile receives the pressure.

FIG. 132

FIG. 133

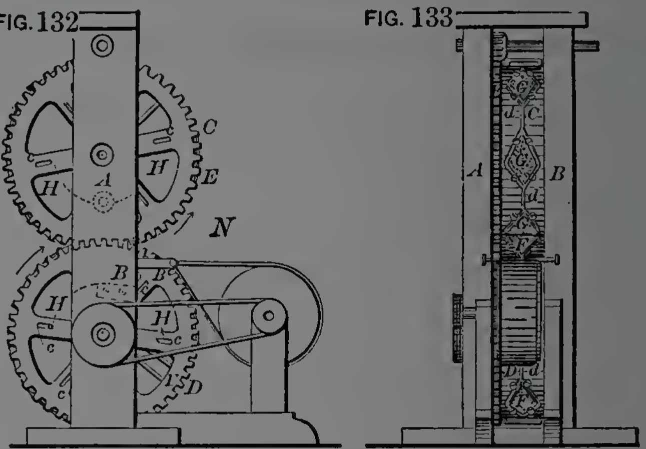


FIG. 134

FIG 135

FIG. 136

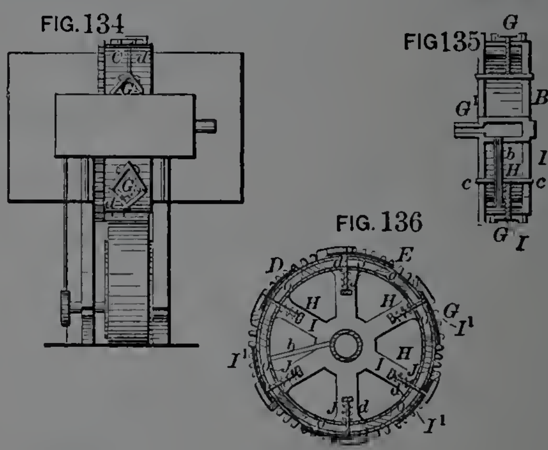


Fig. 132 is a side elevation of the machine. Fig. 133 is an end elevation. Fig. 134 is a plan view. Fig. 135 is a detached transverse section. Fig. 136 is a detached vertical section. Figs. 137, 138, and 139 are detached sections. Figs. 140, 141, and 142 are views of a tile made by the machine. Fig. 143 is a detached section.

Like letters of reference refer to like parts in the several views.

The construction of the various parts of the machine is as follows:—

In the drawing, Fig. 133, *A B* represent a pair of standards, in which are journaled two wheels, *C D*, which engage each other by the gearing *E*. Under each of the dies or moulds is formed a steam-chamber *O*, Fig. 136, into which steam is admitted through the pipe *b*. One end of this pipe terminates in one of the chambers, and the oppo-

Fig. 137

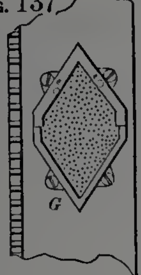


Fig. 138

Fig. 139

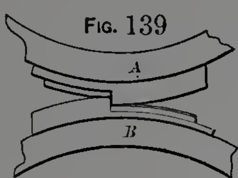


Fig. 140

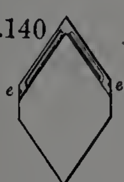


Fig. 141

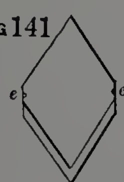


Fig. 142

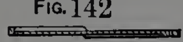
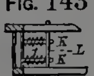


Fig. 143



site end terminates in the hollow shaft G^1 of the wheel, into which steam is received into the boiler. The several steam-chambers are connected to each other, for the transmission of steam by a pipe *d*, Figs. 133 and 134, extending around the wheel from one chamber to another. The purpose of this chamber will presently be shown. In the faces of the wheels referred to is arranged a series of dies or

moulds *F G*, which are so constructed as to give the desired shape to the article to be made, which, in this machine, is a roofing tile. Detached views thereof are shown in Figs. 140 and 141, which give a view of both sides of the tile. The upper and lower dies are constructed substantially alike, differing only in the fact that in the bottom of each of the lower dies is placed a metallic plate or tongue I^1, of the same form as the inside of the die, and upon which the clay is placed and prepared, and whereby the pressed article is forced out from the die by raising the tongue, as will presently be shown. The tongue referred to is raised out of the lower die by a rod *d*, Fig. 136, one end of which is secured to the tongue, whereas the opposite end is secured to a bar *H*, Fig. 136. The two ends of this bar project through slots *c* in the arms *I* of the wheel, in which the bars slide for operating the tongues of the dies. *J*, Fig. 136, is a spring surrounding the rod *d* referred to, the purpose of which is to retain the tongue within the die. Fig. 137 represents an enlarged detached view of one of the dies, the face of which and also the face of the tongue being etched or otherwise made with a roughened surface, so as to confine small portions of air between these surfaces and the clay, which air, when the pressure is removed, will expand and raise or loosen the clay from the roughened surfaces. Fig. 139 represents detached sections of the upper and lower dies, showing their relation to each other while pressing the clay between them; and Fig. 138 shows a longitudinal section of a die, all of which shows the form of the dies for making the tiles, shown in Figs. 140 and 141. In the upper wheel

C, there is an arrangement similar to that in the lower wheel for ejecting the tile, the purpose of which is to punch the nail-holes *e* in the sides of the tile, and which arrangement consists of the two punches *K*, Fig. 143, attached to the sliding head or bar *D*, the ends of which project through slots of the arms of the wheel. The punches are projected through the rim of the wheel into the sides of the dies at the proper place and time to make the nail-holes, as has been explained.

The machine shown in Figs. 144 to 147 is especially designed for the formation of roofing tile from plastic clay; but it may be applied to the formation of any pressed article capable of being shaped between upper and under dies.

The main features of the invention consist of a series of similar lower dies attached to a revolving horizontal table, and brought successively beneath the upper dies, which latter consist of two parts, viz., an outer shell, which forms the edge of the tile, and an upper die, sliding within the shell, and which forms the upper surface of the tile, each attached to suitable slides, and adapted to move independently with a vertical reciprocating motion. In combination with these elements, and moved by the same machinery, is also an automatic feeding apparatus.

Figs. 144, 145, and 146 represent, respectively, a side elevation, a front elevation, and a plan of the tile-machine; and Fig. 147 a perspective view of the dies and shell on an enlarged scale.

The main part of the machine is attached to and sup-

ported by the frame *A*, which stands upon the legs *B B*. Journaled in the upper part of the frame is the shaft *C*, turned by the pulley *D*. On the front of this frame *A* are

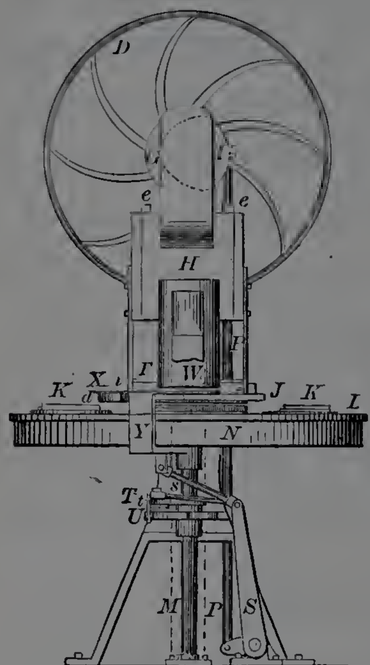


FIG. 145

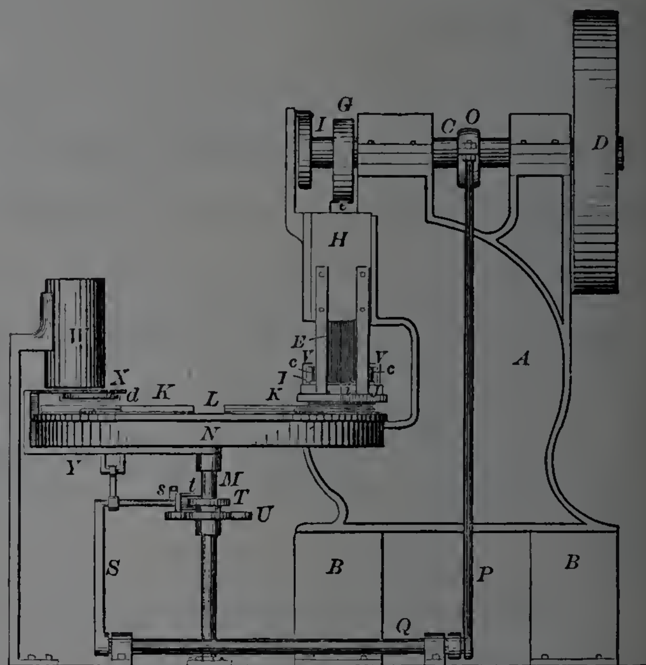


FIG. 144

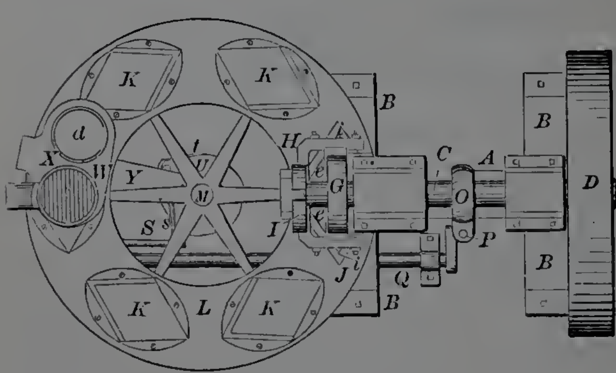


FIG. 146

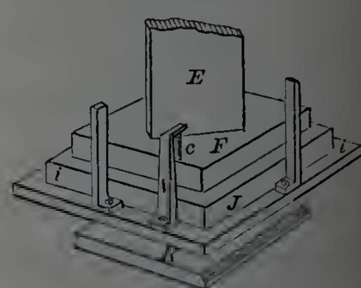


FIG. 147

cast or attached suitable guides *e e*, within which moves the slide *E*, carrying on its lower end the upper die *F*, and moved with a vertical reciprocating motion by the cam *G*. Upon the outside of the guides *e e* is fitted another slide *H*, also having a vertical reciprocating motion, moved by the

cam *I*, and carrying the shell *J*. The lower dies *K K* are attached to the platform *L*, which is keyed to and turned by the shaft *M*. The platform *L* rests upon an annular bed *N*, attached to and supported by the frame *A*, and the upper surface thereof, being planed smoothly, affords a sliding seat, upon which the platform *L* revolves.

In practice, it will be found convenient to have both the annular bed *N* and lower die *F* cast hollow, and charged with steam, when in use, to facilitate the separation of the dies from the tile after the latter is pressed. Upon the shaft *C* is an eccentric-cam *O*, connected to a crank on one end of the shaft *Q* by the rod *P;* and upon the opposite end of the shaft *Q* is a crank-arm *S*, which is connected by a rod *s*, to, and moves a loose collar *T*, on the shaft *M*.

This collar *T* carries a pawl *t*, which engages the ratchet *U* on the shaft *M*, and thereby the cam *O* causes, at each return stroke of the upper die *F* and shell *J*, a partial revolution of the platform *L*, sufficient to bring one of the dies *K*, in position beneath the upper die and shell.

In operation, one of the lower dies *K* being in position beneath the upper die, with a portion of clay thereon, by the action of the cams *I* and *G*, the shell *J* first descends and surrounds the die *K*, to which it is accurately fitted. The upper die then descends within the shell and presses the clay into the desired shape, all excess of clay escaping through the holes *i i* in the ends of the shell *J*. The upper die still remaining on the clay, the shell *J* first ascends; the upper die *F* then ascends; a partial revolution of the platform then ensues, and the operation is repeated.

Especial attention is called to the arrangement of the lower die, shell, and upper die, and the relative motion of the latter two at the time of forming the tile. The upper die at no time entirely leaves the interior of the shell *J*. When the shell *J* descends upon the die *K* the three parts form a closed mould, with the unpressed clay therein.

By causing the shell *J* to rise first, it cuts off the two streams of surplus clay at the holes *i i*, leaves the edges of the tile smooth and clean cut, and permits the upper die to ascend without tearing the green tile, which could not be done if the shell *J* remained down.

In practice it is found that, with every precaution to prevent it, there are always incorporated in the pressed tile particles of compressed air, which, by its expansive force, would, if the die *F* remained at its extreme pressure when the shell *J* was removed, force the clay out laterally between the upper and lower dies, thereby destroying the line and smoothness of the edges of the tile. This is avoided by using an eccentric-cam *G*, to operate the upper die, whereby the upper die begins slowly to ascend the instant after its extreme pressure, thereby permitting the clay to expand upward by the time the shell ascends above it.

Nail-holes are made in the tile as follows: Upon the shell *J* are two standards *V V*, the upper angle whereof is so high as not to interfere with the greatest separation of the upper die and shell. Projecting downward from the top of these are pins *c c*, which pass through holes in the upper die, and of such length that their lower ends shall rest against the face of the lower die *K* when the shell *J* is at its extreme

downward stroke. Their operation will be readily understood from the foregoing description of the press as they follow the motion of the shell *J.*

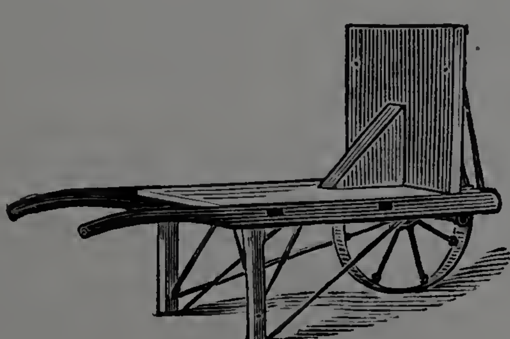
The feeding device consists of a hollow, open cylinder *W*, supported over one of the lower dies when the latter is at rest, as shown.

Across the bottom of this cylinder slides a plate *X*, supported by an arm *Y*, which swings horizontally on the shaft *M*. In this plate is a depression *d*, as large as the interior circumference of the cylinder *W*, the side of said depression toward the centre of the plate being open, and the edge of the plate at that opening sharpened to form a knife. This plate is caused to oscillate across the lower end of the cylinder *W*, by a pittman attached to the crank-arm *S*.

In operation, a roll of tempered clay is placed in said cylinder. By the action of the arm *S*, in revolving the platform *L*, the depression in the plate *X* is brought beneath the cylinder, and into this the roll of clay settles, when, by the return of the plate, a slice of clay is cut off, and falls on the die below.

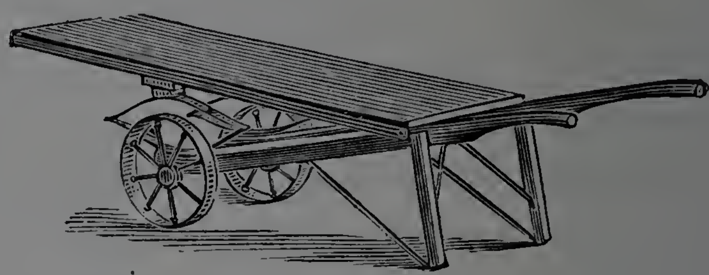
Fig. 148 shows the common form of tile barrows, which

Fig. 148.



are similar to the brick barrows, with the exceptions that they are wider at the front, the back or "dash" is higher, and the wheel is covered. Fig. 149 shows the form of a

Fig. 149.



tile truck designed to carry tiles from the machine to the drying sheds; the usual size of the platform is 28 x 72 inches, and being mounted on two wheels is not easily upset.

The price of the tile barrow is $6.25, and that of the truck $10, and they are manufactured by D. J. C. Arnold, New London, O.

Section III. The Manufacture of Drain Pipes.

Drain tiles are either moulded flat and bent around a *former* to the proper shape, or are made at once of a curved form by pressing the clay in one mechanical operation through a die of the proper form. The latter plan is the one usually employed, and pipes of all the usual sizes can be so produced.

In Staffordshire, England, pipe drain tiles were, and are now in some few cases, made by hand in the following manner: The clay having been first thoroughly tempered is moulded to the required length and thickness, and then

wrapped about a drum, the meeting edges of the clay carefully closed together by hand, the drum or mandril revolved quite rapidly, during which time the pipe tile is shaped by the operator's wet hand, assisted in some cases by a flat curved wooden tool.

Pipe tiles, whether cylindrical, tapered, or egg-shaped, being produced in this manner, the diameter varies from three to eighteen inches.

The Ainslie machine, with many improvements, is now largely employed for making small tubular drain tiles, two pipes of $1\frac{1}{2}$ or 2 inches diameter being produced at the same time.

The tempered clay is forced through two dies to shape the tubes, which are cut into lengths by wires affixed to the machine. When partially dry they are smoothed slightly and rolled straight by hand upon a flat surface, and then set in racks to finish the process of drying.

The hollow fire-proof tiles described in Chapter VI. are formed by compressing the clay through dies, and the hollow bricks, so largely employed for building purposes in many portions of Europe, are also usually formed in this manner.

The idea of tubular tiles and bricks is by no means a new one, for such articles were very largely employed by the Romans in vaultings where lightness of construction was required. Bricks of this character are now in almost common use in this country and in England for many classes of buildings.

The subject of the proper manner of drainage for agricul-

tural lands has received much more attention during the past quarter of a century than it received before that time. Captain Walter Blyth in 1652 directed the attention of the English public to the injurious effects of water retained in cultivated lands.

He condemned the shallow open ditches then in use, and recommended straight trenches reaching below the "cold, spewing, moyst water," which he said was the cause of the "corruption that feeds and nurisheth the rush or flagg." But no attention was paid to this good advice.

More than a century later, in 1764, a Warwickshire farmer conceived the idea of reaching and drawing off the water from the subterranean sources by tapping with an auger the stratum that confined it, and afterwards draining it into one deep channel.

This system came into extensive practice in England as well as in Scotland, and its great imperfections were not fully appreciated until the introduction of the system of James Smith, of Deanton, in 1823.

This was contrived with reference to the removal of the surface water as well as that beneath the soil. A series of parallel drains was sunk in the direction of the most rapid descent, which drains were partially filled with stones small enough to pass through a three-inch ring and then covered over with soil. At the bottom a main drain was constructed generally of stonework or with tiles.

The system grew in spite of great opposition, and finally came to be regarded as the only complete system applicable to all cases.

The drains at last came to be made chiefly of tiles, for the manufacture of which the first machine was invented by the Marquis of Tweeddale.

The practice has been successfully introduced into the United States and other countries, and drain pipes are a considerable branch of manufacture in many portions of the world.

Several kinds of tiles are made for agricultural underground drains, each being suitable under certain circumstances; they are from 2 to 10 inches in diameter, and from 1 to 2 feet in length.

The styles usually employed are termed the pipe tile, which is circular, the sole tile, which is like the letter D laid flat, and the horseshoe tile, which is semicircular and open at the bottom. Any variety may be large or small.

They can be made of about the same kind of sandy clay as bricks, and are burned sufficiently to include as much porosity and toughness as possible.

There is no reason why tiles of this kind cannot be produced cheaply in almost any neighborhood.

The great necessity of underground channels for carrying off the surface waters, and the liquid refuse matter from houses in thickly populated places, for comfort and health, was well understood by the ancient Romans, who had a regular system of drainage, which included not only the pestilential marshes about the city, but by their system of drainage impurities were conveyed from the houses into the main conduits through burned clay and other tubes.

So complete was this system that Pliny called it *urbs pensilis*, a city upon arches.

The ancient Chaldean tomb mounds possess great interest on account of their system of drainage. Long shafts of baked clay extend from the surface of the mound to its base composed of a succession of rings two feet in diameter and about one and one-half feet in width, joined together by thin layers of bitumen.

In America, sewer draining has an ancient history also; the works of the mound builders prove them to have been experts in sewer construction, as has been exhibited at various places between the Northwest and Central America.

In times just past the manner of draining populated dwellings and neighborhood has not received much if any intelligent thought. But now all over the civilized world the matter is receiving great attention, and in many of the large cities of this country the size, kind, and manner of laying drains from dwellings are prescribed by law.

In the District of Columbia a government inspector must see the sewer pipe properly joined and bedded on concrete before the trench in which it is placed is allowed to be closed, a heavy penalty being exacted for the violation of any of the laws on this subject.

The drain pipe for sewerage purposes now employed in this country and in Europe is a glazed terra-cotta or earthenware pipe; it is of various shapes, but the circular form is the one in most general use.

It is made in sections, called lengths, and the diameter is from three inches to three feet, which depends upon the amount of drainage it is to perform.

The clay from which these pipes are made is terra-cotta, or a grade of fire-clay.

The same care has to be exercised in the selection and preparation of this clay as has been described for fire-bricks, but for terra-cotta or earthenware pipes the material should be more plastic, so as to form a close homogeneous body similar to that for architectural terra-cotta.

The clay should be thoroughly mixed, passed through iron rollers (good ones are shown in Chapter VI.), and faithfully tempered. In most of the machines for moulding this kind of ware, now in use, the tempering machinery is connected and forms part; but in others a quantity of clay is placed in a cylinder, which is refilled as it becomes exhausted.

The ware is taken carefully from the tile press, dried, and burned either in the oven used for plain tiles, or in the kiln as for pantiles, both of which have been described in Section 2 of this chapter.

The usual glaze given to the ware is what is termed a salt glaze, which is applied at the final stage of burning, just before the oven or the kiln is closed, when the ware has reached about its highest temperature in the kiln.

The volatilized salt is quickly decomposed, the steam and smoke separating it into hydrochloric acid and soda, and forming a veneering on the surface of the ware by uniting with the silica of the clay.

The manner of applying this glaze, as well as others, is fully described at page 97.

Sometimes the lengths of pipes are made with a projecting flange or socket on the one end, and at other times the pipe is plain, the connection being made with rings, which

are made separate, and are called collars. The latter manner is the usual one with pipes exceeding twelve inches in diameter.

The larger sewer pipes are sometimes made so as to allow smaller-sized pipes to enter them at an angle. S traps, Y branches, T pieces, X and U pieces, elbows, etc., are made for all the different sizes of pipes; they are separately moulded and are somewhat more expensive in proportion than the lengths of pipe.

As in brick-making, so in tile pipe making, there are a very large number of machines intended to economically shape all the different styles of sewer pipe, as well as others to handle it as the pipe comes from the dies, and others still to cut it into rings, etc. Some of these contrivances work very effectively and economically, and others are crude, clumsy, and generally inefficient.

Fig. 150 shows the well-known Tiffany Centennial machine arranged to make twelve-inch tile, with specimens of its work ranging in size from 2 to 18 inches in diameter.

With good clay for the purpose, it makes eighteen-inch tile, and with ordinary clay mould twelve-inch pipes continuously and very rapidly. It possesses very desirable features as a tile machine, besides an adaptation to many other varieties of work.

This machine is driven by a six-inch belt, and has tight and loose pulleys, 6 x 24, which should have a motion of from 200 to 300 revolutions per minute.

The mill shaft has a cog-wheel, 4 inches face and $1\frac{3}{4}$ pitch, simply to do the grinding; for the moulding is done

Fig. 150.

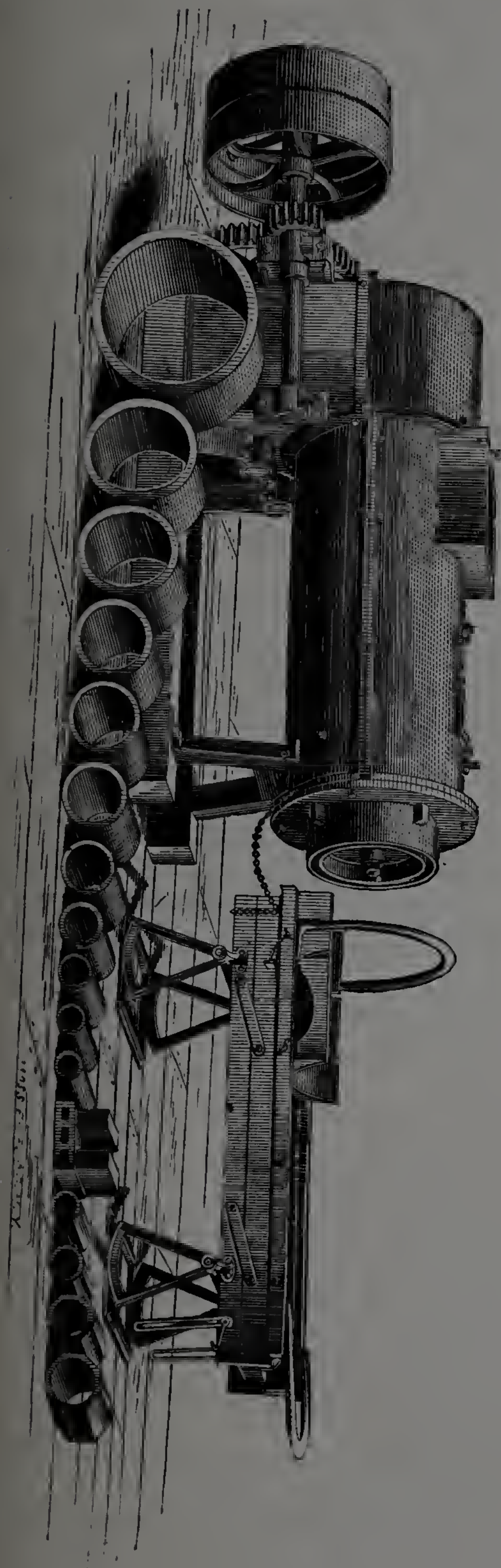
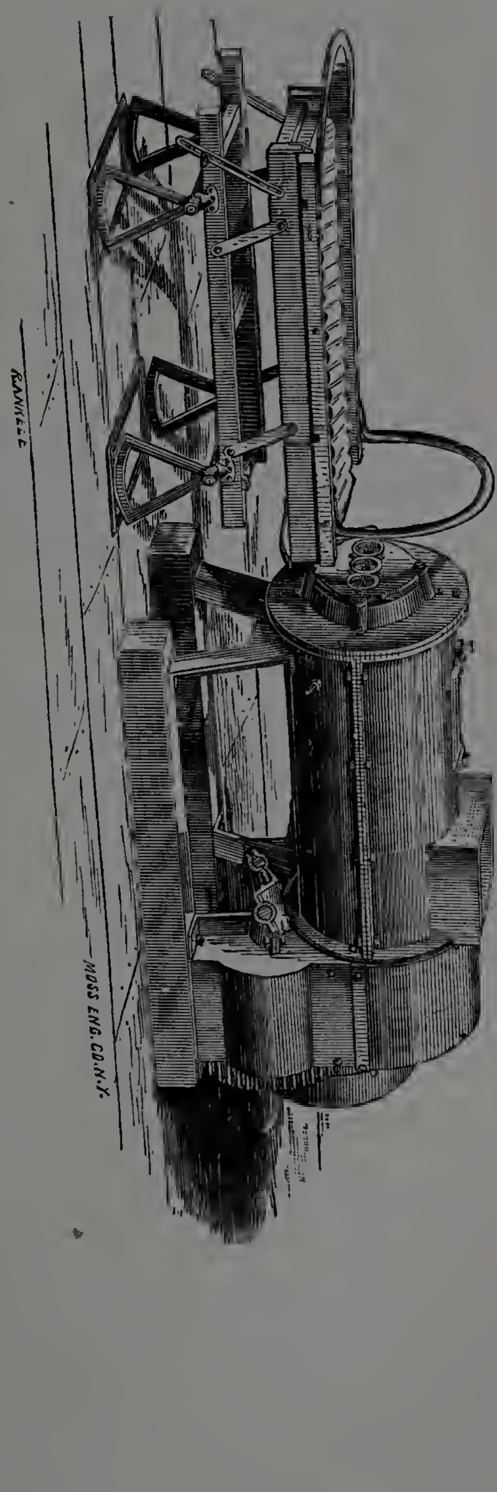


Fig. 151.



by different gearing and by separate shafts, working in different bearings. The great strain which would otherwise be wholly on the mill-shaft and mill-wheel is distributed.

The moulding is done by a propeller on a $2\frac{1}{2}$ inch shaft, passing through the mill-shaft and running at a higher motion in an opposite direction to that of the large propeller on the mill-shaft.

The hopper is 37 inches high, making it very convenient for shovelling directly into the mill, or to carry the clay into the hopper from a crusher.

The machine occupies a space of 30 inches by 10 feet. The knives are attached independently of each other, and may be all taken off through the hopper and door. The propellers are accessible and are readily changed.

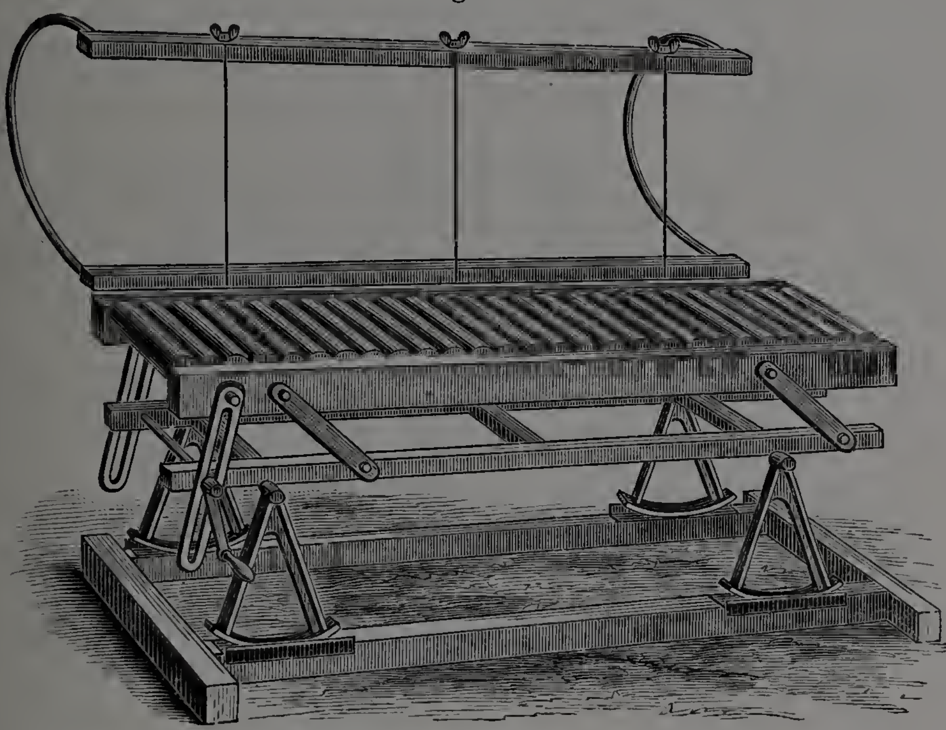
Fig. 151 represents the machine arranged for making two-inch tiles; it has at times been maintained that more than one stream of tile could not be successfully moulded with one propeller; but as this is a double auger mill it performs that difficult operation most acceptably.

The cutting-off table used with this machine as shown in Fig. 152 is operated by a workman. It stands on four rockers, which permit it to be moved longitudinally to and from the machine, to which it is attached by a small chain, and is moved by the web of the clay to the length of the chain, and when the operator wishes to cut the web, he forces the table back toward the machine; then, permitting it to move with the web of the clay, he swings the cutting frame to the opposite side of the table, the strong steel wires passing

through the clay and cutting eight or nine bricks or the tile, as the case may be.

The manufacture of the smaller and larger tile on the Centennial has made necessary an improvement in the elevating devices, the use of hand-screws being too slow a process.

Fig. 152.

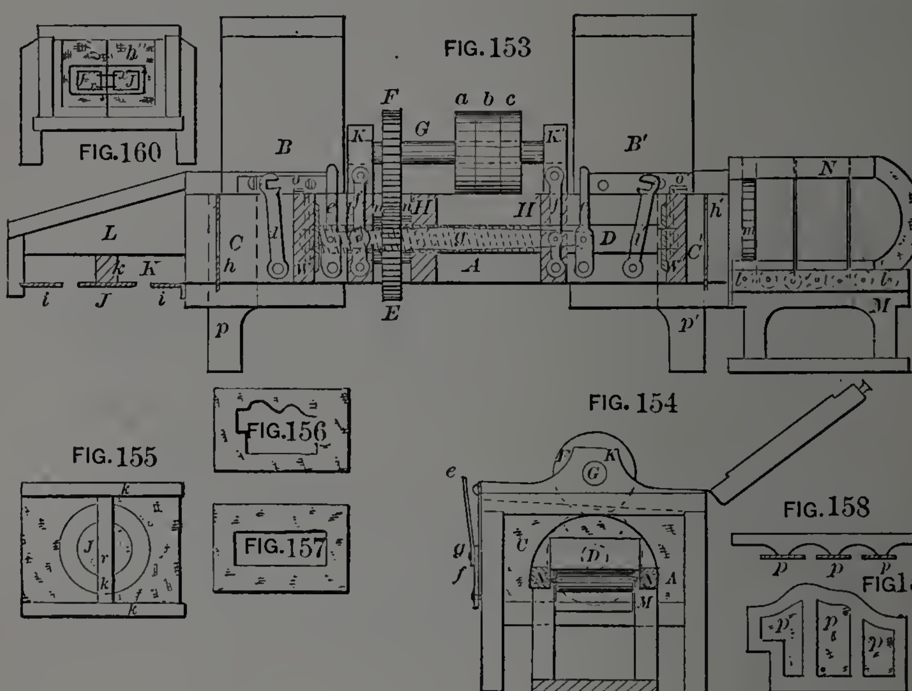


The above cut shows the table as improved for tile-making, and it is so clear that a description is unnecessary.

It will be seen that the table will always be level, and that it may be quickly raised or lowered, and expeditiously fastened at any point, so that it will bear up any weight it has to maintain.

The Drake pipe machine is shown in detail in Figs. 153 to 160, and in addition to forming drain pipes it can be used for moulding hollow bricks, garden borders, etc.

Figure 153 represents a longitudinal elevation with the front cut away; Fig. 154 an end elevation, showing the roller-rack M; Fig. 155, the horizontal die-plate i and adjustable core-pin j, pivoted as shown at r, to its support-frame K, a section thereof being shown in connection with attachment-box L, Fig. 153; Figs. 156 and 157, different styles of die-plates; Figs. 158 and 159, respectively, sectional and



superficial views of an adjustable core-pin consisting of any number of parts, as $p\ p\ p$; Fig. 160, an end elevation, in which is shown another style of core-pin $J''\ J''$, the separate parts being connected by wires $x\ x$. Dividing wire v'' is also shown.

$B\ B'$ are the covers of clay-boxes $C\ C'$, which are symmetrical.

The shaft G is journaled as shown at $K\ K'$, and is provided with driving pulleys $a\ b\ c$. a and c run free on the

axle *G*, one carrying a straight and the other a crossed belt, which are applied alternately to the rigid pulley *b*.

F is the pinion, geared with the wheel *E*, which is provided with a thread, and revolves or turns upon the piston or screw *D*, driving it longitudinally back and forth with the plungers *W W'*, which are attached to either end of *D*.

Heretofore the piston *D*, or "plunger shaft," as it is sometimes called, has been driven back and forth by means of bevel-gear wheels, requiring to accomplish such motion five bevel-wheels and two shafts with spur and pinion wheels.

f f' are knee-joints. *g* is the connecting-rod. *e e'* are levers attached thereto, as shown. When the levers are thrown up, as shown, the pinion is raised, and thereby thrown out of gear with wheel *E*, and the machine stops. The pinion is thrown into gear by moving the levers either to the right or left. In large machines this work is done mechanically.

Clay properly tempered is thrown alternately into the boxes *C C'*, and, by means of the plungers *W W'*, forced out through the die-plates *h h'*, and thereby formed into brick, tile, or mouldings, which are received upon a roller-rack *M*, placed at either end of the machine, and by means of a cutter *N*, provided with wires, as shown, divided into pieces of such length as required.

Prior to this invention, the core-pin and die-plate were cast in a single piece.

The two may be made separate, as shown in Fig. 155, and when so constructed the core-pin becomes adjustable, and the

size and shape of the hollow or opening in the brick, tile, or mouldings may be varied simply by changing the core-pin. Whatever may be the style of core-pin, whether consisting of one or more parts, its holder, which may be about one inch wide and twenty-two inches long in a large machine, is bevelled on the inner side and left flat or with a plane upper surface, so that the clay is made to lap-weld after it passes the holder, and before it passes the core-pin, and thus the brick or tile is prevented from cracking.

The attachment-box L may be used in moulding large tile, which are run down through a die-plate placed horizontally, as shown. Tile may, however, be handled with much greater facility when run out horizontally upon roller-racks. The difficulty heretofore experienced in doing this, when the tile are large, is that when fresh moulded they are liable to collapse or fall in, when placed upon their sides; but by the use of the core-pin J'' J'', Fig. 160, a portion of the clay is left within the opening and serves to support the sides of the tile until they are partially dried. This support then becomes loose and is readily removed. The wires x x divide or separate this support or core as it passes through the die from the sides of the tile, yet leaving it in place, so that it serves to support the tile until they are sufficiently hardened to uphold their own weight, as before described.

The parts J'' J'' may be increased in number and connected by wires, as x x, substantially as shown, and thereby two or more supports may be left within the opening. During this process of moulding large tile the dividing-wire v'' is not used. It is designed for dividing a large tile.

and making thereof two smaller ones, when placed as shown in Fig. 160, and in this latter case the wires x x are removed and the tile comes from the machine with two openings, the portion between the parts J'' J'' of the core-pin being left solid; but on coming against the wire v'' the tile is divided into two parts, either one of which is in itself a complete tile.

By increasing the number of parts J'' J'' of the core-pin, and using the necessary number of dividing wires v'', the number of tile or mouldings that may be run out together may be multiplied.

The Potts machine, shown in detail in Figs. 161 to 170, is for the manufacture of tiles for draining and analogous purposes, it being the object of the invention to produce a mechanism for this purpose which shall be more rapid and reliable in its operation, capable of producing a better article, and of being operated with a less expenditure of power than those heretofore in use.

Figure 161 is a longitudinal vertical section of a mechanism embodying the invention. Fig. 162 is an end elevation of the same. Fig. 163 is an end view of the die-chamber, showing the interior and exterior dies and the manner of adjusting and holding the same in position. Fig. 164 is a horizontal section taken upon the line x x of Fig. 161. Fig. 165 is a side elevation of the driving-cylinder, showing also the reversing mechanism. Fig. 166 is an enlarged view of a portion of Fig. 165. Figs. 167 and 168 are sectional details of the valve for controlling the feed of oil to the driving-cylinder. Fig. 169 is an inside view of the interior

and exterior dies, showing the interior die supported in a different manner; and Fig. 170 is a perspective view of a section of the tile produced.

FIG. 161

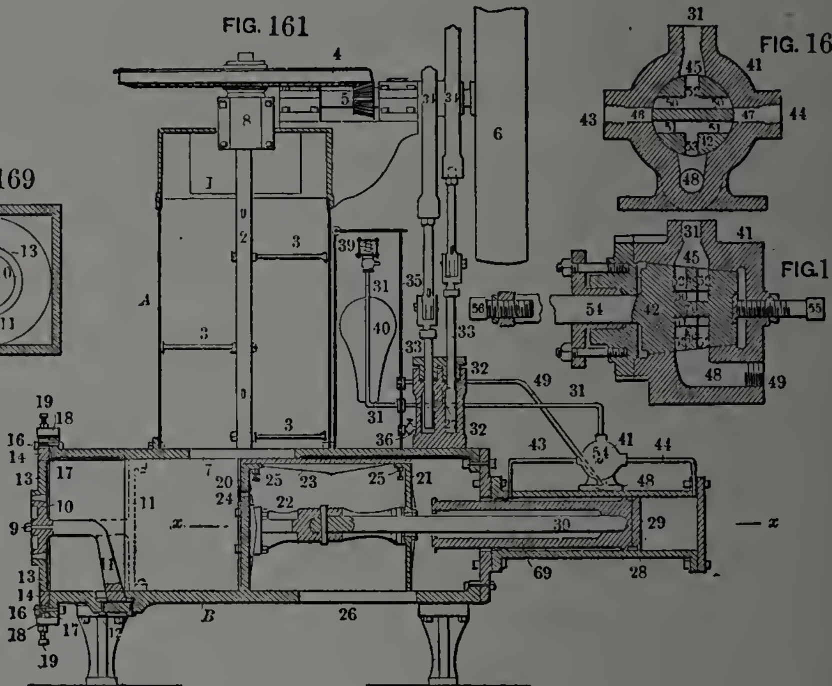


FIG. 168

FIG. 167

FIG. 169

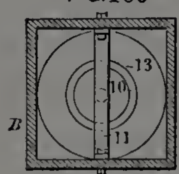


FIG. 166

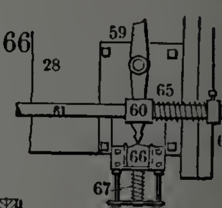


FIG. 164

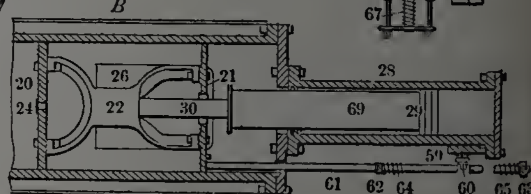


FIG. 165

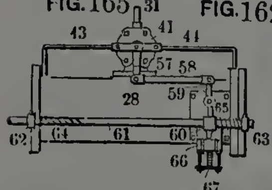


FIG. 162

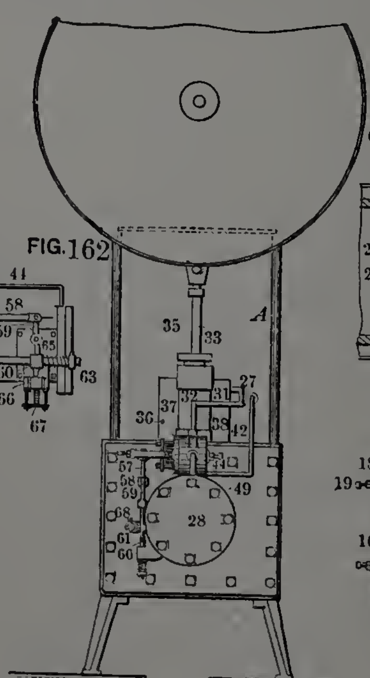


FIG. 163

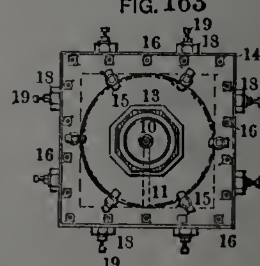
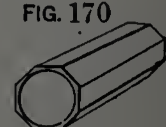


FIG. 170



The cylindrical tempering-hopper *A* is mounted in the usual manner above the die chamber *B*, and is provided at a point near its top with a feeding opening 1, for the reception of the clay. This hopper is also provided with a vertical shaft 2, carrying the tempering-blades 3, the shaft and blades being connected by suitable gears, as 4 5, with a shaft carrying the driving pulley 6.

At the bottom of the tempering-hopper the die-chamber is provided with an opening 7, through which the clay falls after it is properly tempered and in condition to be pressed through the opening formed by the dies.

It will be observed that the bearing 8, through which the tempering-blade shaft passes at the top of the tempering-hopper, is of sufficient length to entirely support the shaft, so that a bearing at its bottom is dispensed with by reason of which the opening 7 is left entirely unobstructed and a free passage afforded for the clay from the hopper to the die-chamber.

The die-chamber *B* is shown, in the present case, as square in cross-section, although it may be of polygonal or of cylindrical form, and is of suitable diameter and length to receive the desired quantity of clay and to permit the plunger to have the proper length of stroke. The forward end of the die-chamber is provided with the various parts constituting the die, through which the clay is pressed to give the proper shape to the tile. These parts consist of an interior die, an exterior die, and an adjustable supporting-frame carrying the latter. The interior die 10, around which the tile is formed, and which serves to determine its

interior configuration, is removably supported upon an arm or bracket 11, which may be of the form shown in Fig. 161, and secured by bolts 12 to one side of the interior of the die-chamber. This support may, however, extend across and be secured to both sides of the chamber, as shown in Fig. 169, and by dotted lines in Fig. 161. The exterior die 13, through which the tile passes, and which serves to determine its exterior configuration, is seated in an opening in the supporting-frame or die-carrier 14, it being secured to said frame by a series of buttons or catches 15, as clearly shown in Fig. 163. The carrier or frame 14, supporting the exterior die, is adjustably secured to the forward end of the die-chamber by means of the series of bolts 16, which pass through flanges upon the sides of the chamber and enlarged openings 17 in the frame, as shown in Fig. 161.

To aid in properly adjusting the frame 14 and securing it in any adjusted position, the end of the die-chamber is provided with the series of projecting ears 18, through which pass set-screws 19, the inner ends of which abut against the frame and support it upon all sides. By means of these devices it will readily be seen that the exterior die can be set in any desired relation to the interior die, so as to produce tile of uniform thickness upon all sides, or of uneven thickness, which latter is often desirable. It will also be seen that by changing the interior or exterior die, or both, which can readily be done, thicker or thinner or larger or smaller tile can be produced at pleasure, and also that dies of different forms may be substituted, so as to vary the exterior or interior configuration of the tile, or both.

The reciprocating plunger with which the die-chamber is provided, and by which the clay delivered from the tempering-hopper is pressed through the opening in the die, consists essentially of a pair of heads 20 21, connected by a yoke 22, and a top plate 23. The heads 20 21 fill the entire area of the chamber, substantially like pistons, and the head 20 is provided with an ordinary flap or other valve 24, so arranged that, as the plunger moves backward, air will be allowed to enter the die-chamber and prevent the formation of a vacuum in front of the plunger. The plate 23, which connects the front and rear heads of the plunger, extends the entire width of the die-chamber, or is at least of sufficient width to cover the opening 7, and prevent the clay from falling in the rear of the head 20 when the plunger is at the forward end of its travel. This plate is also made slightly adjustable by means of set-screws 25, so that it can be moved outward to compensate for wear.

The bottom of the die-chamber is provided with an opening 26, located as shown in Figs. 161 and 164, through which the interior of the chamber can be reached for the adjustment of the parts.

The plunger just described is operated to press the clay through the opening in the die by means of hydraulic or other analogous pressure applied from the cylinder 28 upon the rear end of the die-chamber through the piston 29 and piston-rod 30, the latter of which passes through the head 21, and is secured to the yoke 22, as clearly shown in Figs. 161 and 164.

The fluid (preferably oil or some other substance which

is nearly or quite non-compressible), which drives the piston 29, is forced into the cylinder 28 through a main pipe, as 31, connected with any appropriate form of pumping apparatus operated either from some moving part of the machine or independently thereof, as may be desired. In the present case this pumping apparatus is shown as consisting of a double force-pump 32, the pistons 33 whereof are connected with and driven by excentrics 34 upon the driving-shaft of the machine. These pumps are provided with valves, so arranged in the ordinary manner that the motion of their pistons draws the oil or other fluid from the tank 35, through pipe 36 and chamber 37, into the pumps, and ejects the same through chamber 38 and pipe 27 into the pipe 31. One end of the main pipe 31 enters and terminates near the top of the tank 35, as shown in Fig. 161, at which point it is provided with a safety-valve 39, controlled by a spring or other device which can be adjusted, so that in case the plunger meets with any undue resistance, as would happen if a stone or other solid substance should pass into the die-chamber, a relief may be afforded to the pressure of the fluid in the cylinder 28, and all danger of breaking the machine be avoided. This pipe also communicates with an air-chamber 40, in which the elasticity of the confined air serves to make the movements of the piston regular and uniform. The opposite end of the pipe 31 enters the valve-chamber 41, which contains an oscillating valve 42, which operates to direct the oil or other fluid alternately through the pipes 43 44 and into the cylinder 28 upon the opposite sides of the piston 29.

Referring particularly to Figs. 167 and 168, it will be seen that the valve-chamber 41 consists of a cylindrical casing provided with ports 45 46 47, communicating respectively with pipes 31 43 44, and with a port 48, communicating with the exhaust-pipe 49, through which the motor-fluid is returned to the tank 35. The valve 42 consists of a slightly tapering cylindrical plug provided with parallel passages 50 51, which may be made to communicate with ports 46 47 and branch passages 52 53, which open into ports 45 48. To give greater strength to the plug the passages 50 51 52 53 are provided with a partition-wall 68, as shown in Fig. 167. This plug is provided with a stem 54, extending through the wall of the valve-chamber, and with adjusting-screws 55 56, located as shown, by which it can be maintained in such position as to preserve a perfectly tight joint between it and the casing.

The stem 54 is provided with an arm 57 (see Fig. 165), which is connected by a link 58, with a pivoted lever 59, the end of which is loosely connected to a collar 60, which slides freely upon the valve-rod 61, which is connected to the head 21 of the plunger. The rod 61 is provided with two adjustable collars 62 63, which, by means of set-screws, can be secured to the rod in any desired position, and is also provided between said collars with springs 64 65, the purpose of which will hereinafter appear. The end of the lever 59 extends below the collar 60, and engages with the face of a double-inclined block 66, which slides in suitable ways secured to the side of the cylinder 28, and is pressed upward against the end of said lever by a spring 67, as shown in Figs. 165 and 166.

The operation of the mechanism just described is as follows: The clay, being introduced through the opening 1 into the tempering-hopper, will pass gradually downward in the hopper, being tempered during its passage by the blades 3. As it arrives at the bottom of the hopper the tempered clay passes through the opening 7 into the die-chamber in front of the plunger. When a sufficient quantity of the clay has thus passed into the die-chamber, the pumps will be started, and the fluid, forced into the cylinder 28, behind the piston 29, will cause the plunger to advance, thereby forcing the clay through the die-opening and forming the tile as shown in Fig. 165. When the plunger has thus advanced a proper distance the spring 65 will come into contact with the collar 60, and said spring will be compressed until it has acquired sufficient tension to move the lever 59 against the resistance of the inclined block 66. As soon as the lever 59 is started the expansion of the spring 65 will throw its end quickly over the apex of the block 66, when the expansion of the spring 67 will at once raise the block to its normal position. This movement of the lever 59 will, through link 58 and arm 57, turn the valve 42, so as to permit the fluid forced into the pipe 31 to pass through port 45, passages 52 50, port 46, and pipe 43 into the cylinder in front of the piston 29, to retract the plunger. At the same time that a passage is thus opened for the admission of the fluid to the cylinder in front of the piston a passage will be opened through pipe 44, port 48, passages 53 51, port 47, and pipe 49, which will permit the fluid in the rear of the piston to pass back to the tank 35. When the

piston has gained the rear end of its stroke, the spring 64 will come into contact with the collar 60, and the valve will in like manner be moved in the opposite direction, so as to admit the fluid through port 45, passages 52 50, port 47, and pipe 44 to the cylinder behind the piston, thereby causing the plunger to again advance, while at the same time the fluid in front of the piston will be allowed to escape through pipe 43, port 46, passages 51 53, and port 48.

By reason of the cylindrical sleeve 69, which surrounds the piston-rod in front of the piston, the front area of the piston is reduced to one-third or less than one-third of its rear area, from which it results that the piston and plunger are retracted very much more rapidly than they are advanced, thus effecting a great increase in the rapidity of the operation of the machine.

It is to be observed that the partition 70, which separates the passages 50 51 in the valve, is slightly less in thickness than the diameter of the ports 46 47, from which it results that in reversing the piston there is never a time when the passage of the fluid through the valve is entirely arrested, it being allowed to enter the passage 50 before it is entirely shut off from the passage 51, and *vice versa*. This feature relieves the strain to which the valve would be subjected by totally arresting the flow of the fluid.

It will readily be seen that by varying the positions of the collars 62 63, the length of the stroke of the piston and plunger, and the amount of clay delivered through the die can be regulated at pleasure.

As before stated, the pump 32 may be of any approved

construction, and may be operated by or independently of the machine.

Instead of a double pump, as shown, a single pump may be used, although the former is preferable, as it gives a uniform movement to the plunger.

By varying the quantity of fluid fed to the pump, for which purpose the pipe 36 is provided with a regulating-cock, as shown in Fig. 161, or pumps, it will readily be seen that the speed of the plunger can be varied at pleasure. This is an important feature, as in making tile of large size the plunger can be operated successfully at a much greater speed than when small-sized tile are being made, and also because by this means the amount of tempering to which the clay is subjected can be easily regulated.

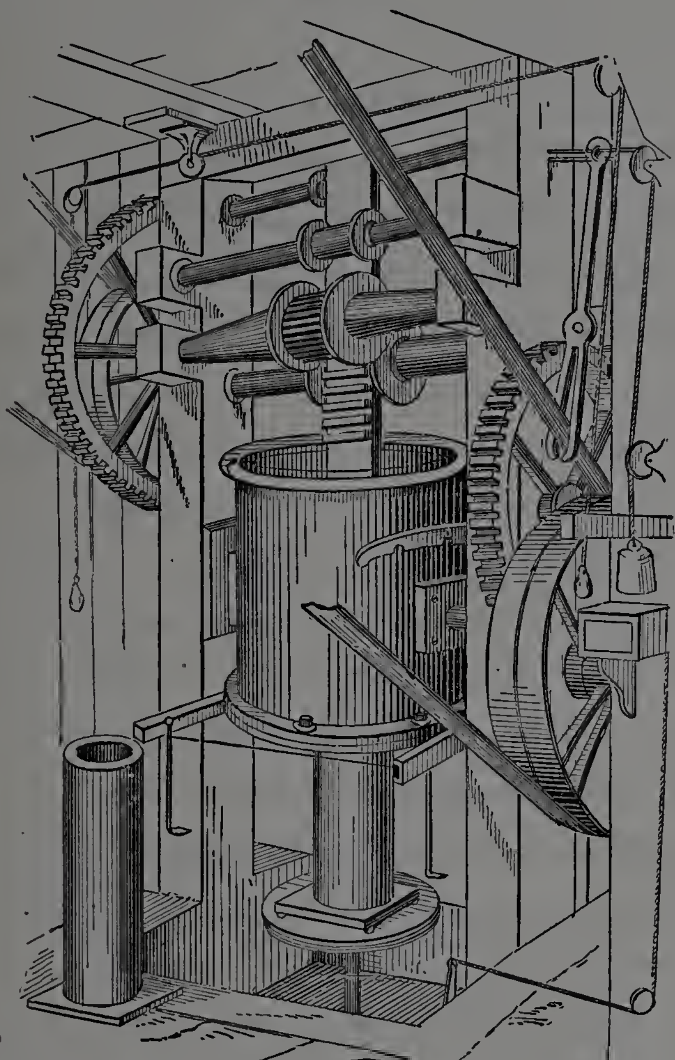
Fig. 171 shows an old style of pipe machine much in use in Europe and in this country for forming large-sized pipes.

The exterior cylinder contains a second cylinder which holds a given quantity of clay. By the rack the clay is forced by the piston through the die upon a balanced table, which is forced down, and when the proper length of pipe is formed, the belt is shifted, and the machine stops; the length of pipe is cut off by the wire shown under the cylinder.

The pipe is removed, the table raises, and the machine is again set in motion, and the operation continued as before, and when all the clay in the cylinder has been used, the rack is reversed, the plunger drawn entirely out, and the cylinder, which moves on pivots, is tilted, to receive another

charge of clay, then restored to its vertical position to be again quickly emptied. This class of machines is as clumsy as it is unprofitable; they cannot be run, on an average,

Fig. 171.



for more than one-quarter of the day, the other three-quarters being lost in the stops of the machine, which are too long, as well as too often, owing to the awkward construction of some of the parts.

Section IV. Machines for forming Sockets on and making Curved Earthenware Pipes.

The machine shown in Figs. 172 to 178, and that shown in Figs. 179 to 181 are the inventions of Mr. Horace B. Camp.

The first invention shown in Figs. 172 to 178 has relation to that class of machinery for making pipes of clay or other plastic material by pressing it through an annular orifice between an outside die and an inside core, and its object is to form sockets on the end of sections of such pipe when the pipe is caused to curve as it issues from the orifice.

In order to present the distinctive features of the invention, it is proper to state that ordinarily to form such sockets on sections of straight pipe, the outer die is prolonged beyond the point of discharge of such length and inside shape as to form the outside of the desired socket. When, however, the pipe curves as it issues from the orifice, this device is impossible, as the issuing pipe encounters the edge of this socket-die and is destroyed. To obviate this difficulty, Camp constructs the socket-die separate from the other parts of the machine, in the form of a ring, divided into two parts, so as to permit of its being removed: and the first part of this invention relates to the method of holding this severed ring firmly in place until the socket is formed, which consists in fitting its upper edge into a groove in the lower face of the outside die, and its lower edge into a groove in a flange projecting from the base of the die, which forms the inside of the socket; and the second part of the invention relates to a combina-

tion of arms and links for manipulating the parts of the ring.

For the purposes of this description, we adopt the following nomenclature:—

That part of the pipe-press which forms the outside of the annular orifice through which the pipe issues—the outside die. The piece suspended centrally within this, and which forms the bore of the pipe—the core. The die which forms the inside of the socket—the lower die; and the severed ring which is interposed between the outside die and the flange of the lower die, and forms the outside of the socket—the ring.

Figure 172 is a sectional view of a portion of the lower part of a pipe-press, wherein *A* is the outside die, and *B* the core; the outside die *A* having a groove *S* in its lower face to receive the upper edge of the ring.

Fig. 173 is a central section of the ring *C*, divided in half at the line *a* (a plan of which is shown in Fig. 178), and having its upper edge turned to accurately fit in the groove *S*, in the outside die *A*, and its lower edge fitted in the same manner for the groove *R* of the flange of the lower die *D*.

Fig. 174 is a side view of one of the hooks *H*.

Fig. 176 is a plan and Fig. 175 a section at the line *x x* of the lower die *D*. Upon alternate sides of the flange of this die are two lugs *d d*, which lock into hooks *H H* attached to the outside die *A*, and hold the several parts together while the socket is formed.

In operation the lower die *D*, by means of the collar *E*

projecting from its base, rests upon a following rod (not shown), which moves in the line of the axis of the press. The ring *C* is then placed thereon, with its lower edge fitting into the groove *R*. The whole is then raised to the press, the upper part of the lower die *D* joining, and forming a continuation of the core *B*, and the ring *C* entering into the groove *S*. The lower die *D* is then revolved until the lugs *d d* lock into the hooks *H H*, as shown in Fig. 177, the whole forming a complete mould for the socket. When the socket is formed the lower die *D* is withdrawn, and the ring *C* separated and removed.

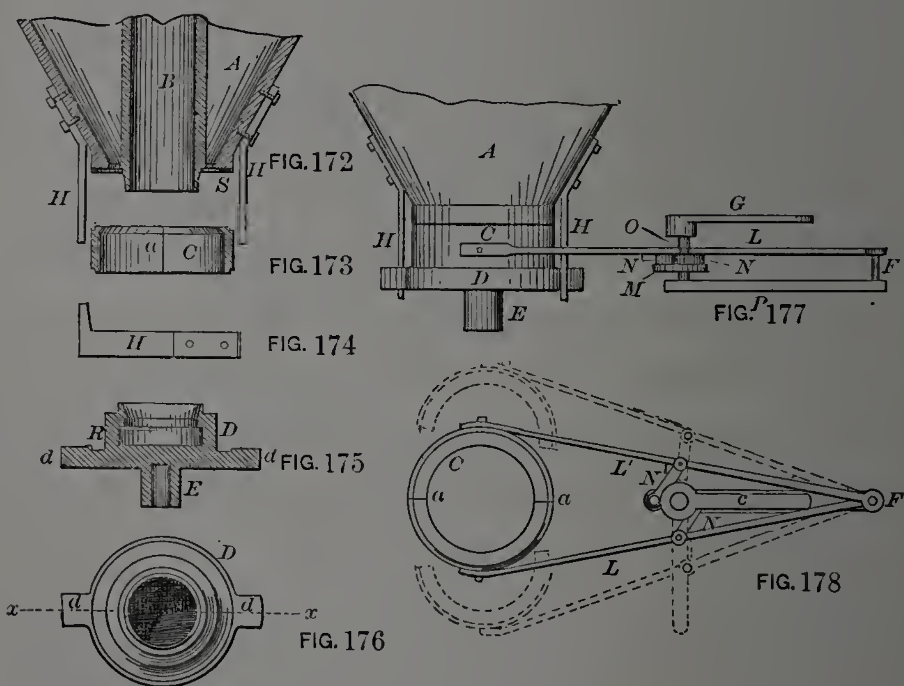


FIG. 172 FIG. 173 FIG. 174 FIG. 175 FIG. 176 FIG. 177 FIG. 178

To facilitate the manipulation of the ring *C* the inventor attaches to the segments thereof the arms *L L′* (see Figs. 177 and 178), hinged upon the wrist *F* attached to the bar *P*. Upon the wrist *O*, journaled in the bar *P*, are fastened

the lever G and link M, and opposite ends of the link M are connected with the arms L L' by the links N N', the whole so arranged that by revolving the lever G the arms L L' may be caused to diverge or approach each other, carrying the segments of the ring C.

The simple divided ring C, for the purpose of making sockets on sections of straight pipe, is not new, but the method of holding it by means of the grooves in the dies A and D, and manipulating it by means of the arms L L' and attachments, Camp believes to be original with himself.

Making Curved Earthenware Pipes.

The invention shown in Figs. 179 to 181 relates to the formation of curves, elbows, and traps in that class of sewer and water pipe made of clay or similar material by being pressed, while in a soft and plastic condition, through an annular orifice between an outside die and an inside core or mandrel, and subsequently burned and vitrified, but it may be applied to any pipe made in the same manner.

The object of the invention is to rapidly and easily form such curves, and so form them that they shall be of even thickness in every part.

Figure 179 represents a central vertical section of a portion of an ordinary cylinder and attachments for making pipe, embodying this invention.

To the cylinder A, from which the clay is pressed to form the pipe, by a piston (not shown), is bolted a cylinder-head C, made converging to facilitate the descent of the clay.

To the head C is bolted the outside hollow die D, having an inside diameter at the bottom of the size of the desired pipe, and within which, supported centrally by means of the rod F, is the core or mandrel M, having an outside diameter of the size of the inside of the desired pipe. Between the die D and head C is a chamber or recess, in which is fitted a plate P, Fig. 180, free to slide longitudinally in one direction at right angles to the main cylinder and core, and moved by means of a lever L, which said lever is attached to the plate P by the bolt Q, and is hinged to the lugs R and T cast or attached to the head C and die D, respectively, as will appear from Fig. 181, which represents a transverse section of Fig. 179 at the bottom of the plate P, looking from below. Through the plate P is an orifice of the shape, and approximately of the size, of the pipe to be made, within which the mandrel is suspended, and having the edges bevelled from the upper surface outward. When the plate P remains so that the core M is exactly in the centre of the orifice therein, the clay descends with the same rapidity on all sides of the core, and is discharged in a continuous straight pipe. By sliding the plate to one side, the space S between the edge of the orifice in

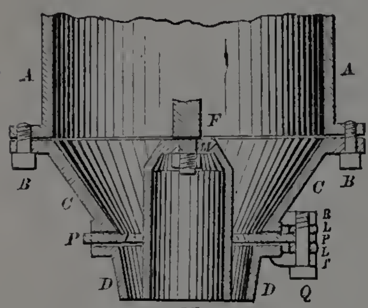


Fig. 179

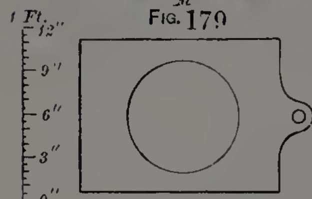


Fig. 180

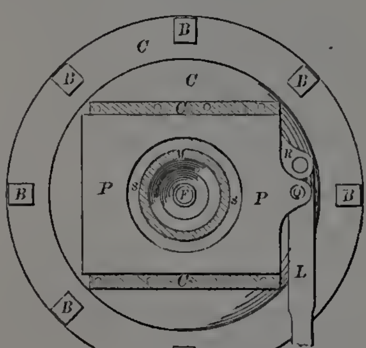


Fig. 181

the plate *P* and the mandrel is lessened on one side, and correspondingly increased on the other. The result of this is that the clay descends and escapes more rapidly on the opened side of the mandrel than on the side where the space *S* is contracted, and as it is discharged from the die *D*, it curves toward the side on which the space is contracted. By sliding the plate to the other side, the pipe will curve in an opposite direction, and by a succession of movements of the plate, any desired form of curve or trap can be made. The relative positions of the die *D* and core *M* remain at all times unchanged, and as a result the pipe is of equal thickness on all sides.

The principle of curving such pipes, by allowing the clay to discharge more freely on one side of an annular orifice than on the other is not new, as the inventor, as well as others, had for several years previous to this invention made single curves by rigidly setting either the core *M* or die *D* to one side of their common centre, so as to be eccentric to the other, thereby making the annular orifice, when the pipe is discharged, larger on one side than on the other. Nor is the idea new of making parts of a pipe-machine movable at the will of the operator while the pipe is issuing, thereby enabling him to make reverse or other compound curves, as several devices have been invented and patented for moving either the die *D* or mandrel *M*, while the pipe was forming. But all these devices have reference to a change in the annular opening between the core *M* and die *D* at the point of discharge, and herein they differ radically from this, in that the pipe is of uneven thickness on different sides.

Dodd's Improved Tile Carrier for Horizontal Tile Machines.

The invention is shown in Figs. 182 to 184, and relates to an improvement in that class of tile machines employed in making drain-tile, in which the tile as it issues from the forming-dies is received upon an endless belt or carrier, where the tile is cut to proper lengths, the object being to so construct the carrier that tile of different sizes or diameters may be carried by one and the same set of supporting-bars, instead of being compelled to change the bars for others having a concavity formed to suit the periphery of every different size of tile manufactured. This result is accomplished by forming the concavity in the carrier-bar upon as great a radius as that of the largest tile to be made upon the machine, and then bridging the space between the ends of the bar with a strap of flexible material, upon which the tile is received. This flexible strap conforms to the outer surface of the tile and prevents it from becoming flattened or otherwise disfigured in shape, as would be the case were it carried by bars which did not conform to its surface while in the soft and plastic state in which it issues from the dies of the machine.

The invention consists, therefore, in the combination, with the carrier-bars, of a flexible strap, by means of which the carrier-bar is made to conform to the shape of tile of different diameters.

Fig. 182 is a perspective view of a carrier complete having its carrier-bars provided with flexible straps. Fig. 183 is a cross-section of a carrier, showing the position assumed

by the flexible strap when carrying a tile. Fig. 184 is a perspective view of one of the bars and straps, with a section of the carrier-belt.

In constructing this machine the carrier-frame *A* is formed in the usual manner of two side pieces connected by cross-

FIG. 182

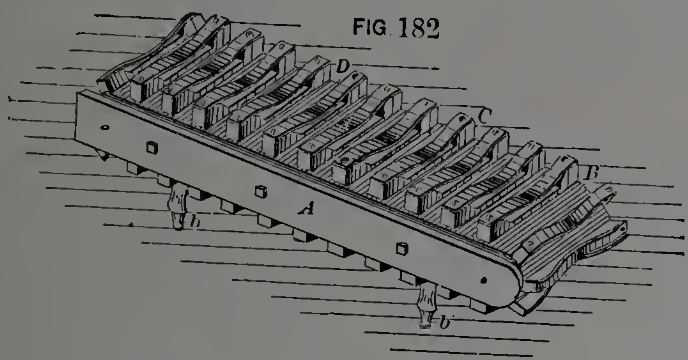


FIG. 183

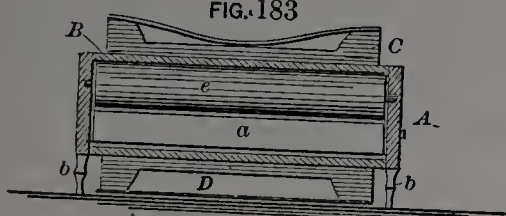
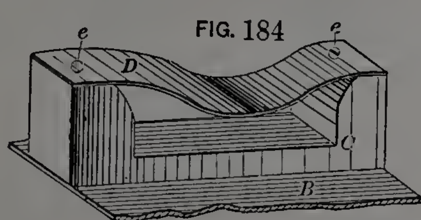


FIG. 184



bars *a*, and supported upon short legs *b*, or by any other suitable means. Above the cross-bars *a*, which connect the two sides of the frame, is placed a series of rollers *c*, which support the endless carrier-belt or belts *B*. To this belt are secured by screws or other proper means the carrier-bars *C*. These bars have a cavity or hollow in the side opposite that which is attached to the carrier-belt, and bridging this cavity is the flexible strap *D*, secured at each end to the

carrier-bars *C* by means of screws *e* or other proper fastening devices. These straps *D* may be formed of leather, rubber belting, canvas, or any other material possessing sufficient strength and flexibility, it being necessary that they should give a firm support to the tile and at the same time conform readily to its shape. In attaching these straps *D* to the carrier-bars it is preferable to allow the strap to drop or sag a little, as is clearly shown in Fig. 184 of the drawings, as it is thereby caused to conform more readily to the shape of the tile.

The frame provided with carrier-belt and carrier-bars having a concave receiving surface to receive the tile as it comes from the forming-dies are old, but the combination of the carrier-bars and a flexible bridging strap arranged to receive the tile as it issues from the forming-die is a new idea.

A Contrivance for Preventing the Displacement of Drain-Pipes in the Kiln.

The contrivance shown in Figs. 188 to 191 is the invention of Mr. John Murtagh, of Boston, Mass., and is for holding or binding the upper course of pipes during the process of burning, and the application of this arrangement in works of any magnitude cannot fail to result in considerable savings.

In the manufacture of drain-pipe it not unfrequently happens that much of the pipe comes out of the kiln in which it is burned in a greatly damaged condition, the pipes hav-

ing gotten out of place during the burning, and become bent or adhering together in masses.

The object of this invention is to prevent the displacement of the pipes when in the kiln; and the invention consists in securing each pipe of the top tier in the kiln to its neighbors, by means of binders made of clay like that of which the pipes are made, and baked or burned in the manner

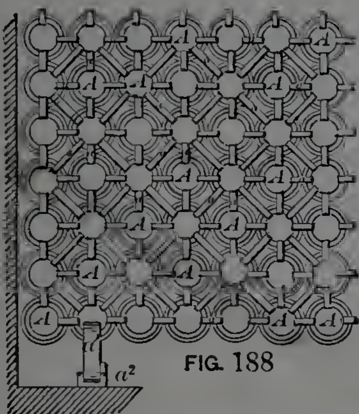


FIG. 188

FIG. 189

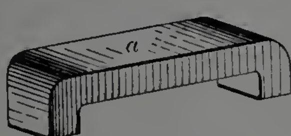


FIG. 185

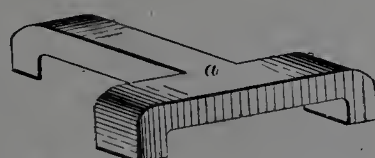


FIG. 186

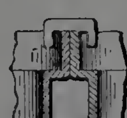


FIG. 190

FIG. 191

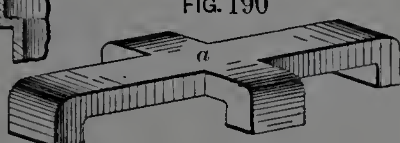


FIG. 187

usual in this art. Figs. 188 and 189 are diagrams, Fig. 188 illustrating the new mode of securing the top tier of pipes in one way, and Fig. 189 in another, both ways of arranging the top tier being in common use.

Figs. 185, 186, and 187 show three forms of binders.

Figs. 188 and 189 illustrate two modes of arranging the upper tier of pipes in the kiln. Figs. 190 and 191 illustrate the relation of the pipes and binders before and after burning.

The binders *a* are formed of the clay used in making the pipe, or of other suitable clay, with a body-piece, from which project two or more legs, as shown in Figs. 185, 186, and 187, and then burned in a proper kiln, as the pipes are burned. The mode of forming and burning them will be well understood by all skilled in the art without further description. When thus made they are hard, and although brittle, like other crockery or pottery ware, are yet abundantly strong for the purpose. They may be used again and again in the kiln, the heat of which has no effect, except to harden them more each time they are used; and they stand the heat of the kiln well, and are in all respects admirably adapted for their intended use. One set of them can be used from twenty to thirty times before they become too much vitrified.

In filling the kiln the unburned pipes are placed in the usual way; but the pipes in the upper tier are connected each with its neighbors by these binders, as illustrated in Figs. 188 and 189, where *A* represents the pipes, and *a* the binders. This makes the upper layer of pipes one compact mass, and does away completely with all danger of their getting out of place in burning. Binders a^1 are used to connect the tier of pipes with the wall of the kiln, special bricks a^2 being built into the wall to engage with the end of the binders.

It is customary to place elbows and other connecting pipes on top of the upper tier in filling the kiln, and these binders make a floor much better adapted for receiving these elbows and connections than the upper ends of the upper tier of pipes.

The practical use of this invention has demonstrated that the waste from this source, which has heretofore been one of the most serious sources of loss in this manufacture, is entirely done away with. So far as I know, the present inventor is the first to devise any practical remedy for this evil.

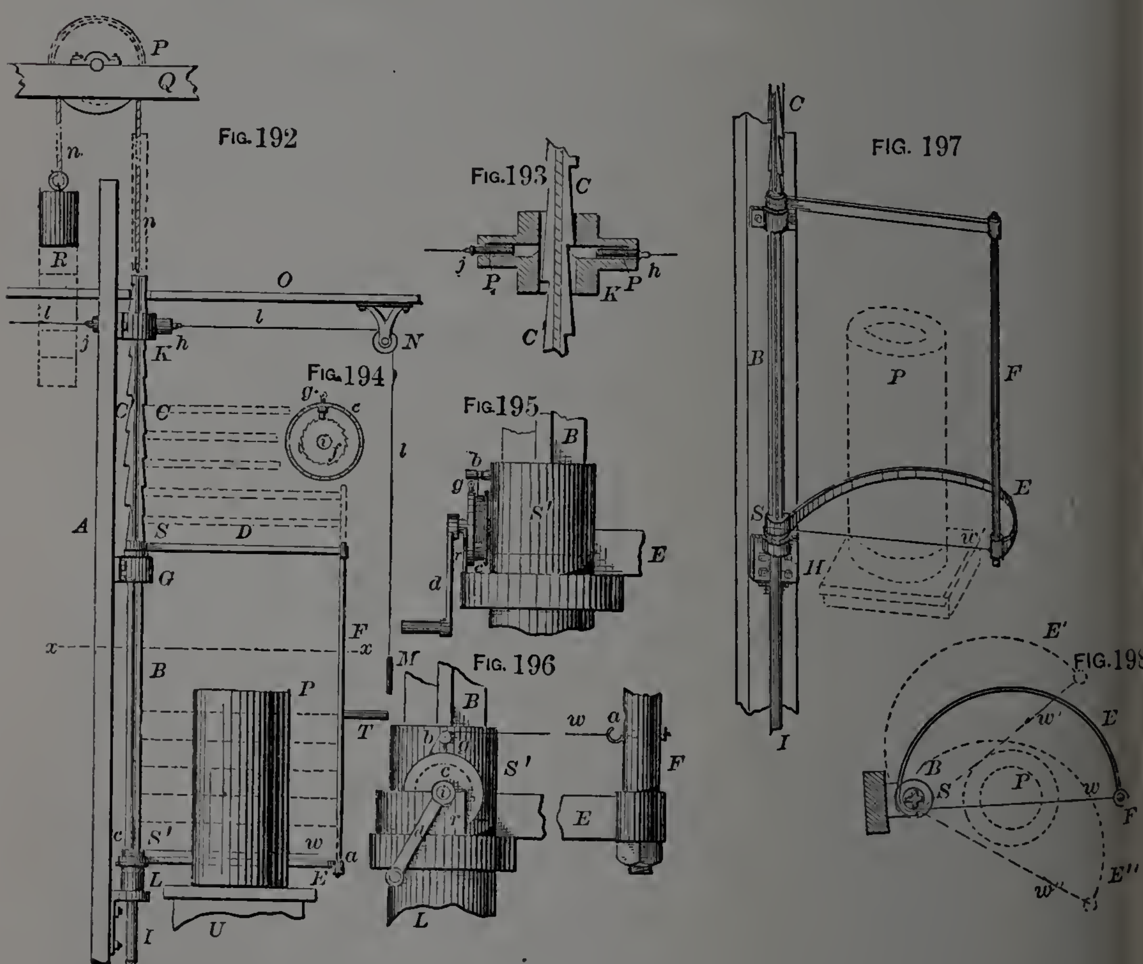
The pipes shrink in burning, so that the binders should fit loosely when the kiln is set, as shown in Fig. 190. Fig. 191 shows the position of the pipes after they are burned.

Machine for Cutting Sewer Pipe Rings.

The object of the invention shown in Figs. 192 to 198 is the production of a machine for cutting rings from clay pipe while in the green or undried condition in which they are formed; and which rings are designed, after burning, to be employed in the construction of drains and sewers, or for other purposes; and the invention consists in a horizontally vibrating wire-carrying frame arranged to swing over a suitable pipe-supporting platform, and capable of being moved vertically between each vibration and supported in place during each motion, so that the pipe is divided by vibrating wire into successive rings.

Figure 192 is a side elevation of a ring-cutter embodying

these improvements. Fig. 193 is a vertical section through the upper socket, showing the catches which support the racks and wire frame. Fig. 194 is a sectional view, showing the ratchet of the wire-reel. Fig. 195 is an end view of the wire-reel on an enlarged scale, showing its mode of attachment to the lower arm of the wire-frame. Fig. 196 is



a side view of the same. Fig. 197 is a perspective view. Fig. 198 is a sectional view on the line x x, Fig. 192.

A, Fig. 192, is an upright post or other suitable support, to which the swinging wire-carrying frame is attached by means of the lugs or sockets *L G K* and the sliding bar *B*.

P is the pipe, resting on the fixed platform or stand *U*, and *w* the wire strained on the swinging frame, by which the pipe is cut.

R is a counter-weight, by which the swinging frame is balanced; and C C^1 are the racks, and *h j* the catches by which the length of the rings is determined.

The swinging frame employed consists preferably of an upper horizontal arm *D*, an upright connecting-rod *F*, and a lower curved arm *E*. The inner or pivotal ends of the horizontal arms are formed into rings or journals S S^1, which turn freely on socket-pieces affixed to the upright bar *B*, which has the capacity of sliding vertically up and down through the sockets *L G K*, carrying the swinging frame with it. The weight of the swinging frame and the bar *B* is nearly counterbalanced by a weight *R*, attached to a cord *n*, which passes over the pulley *P*, secured on any suitable support *Q*, in such fashion that very little effort is required to move the frame and bar upward.

In order to provide for cutting rings of different lengths, two or more racks C C^1 are made on the upper end of the bar *B*. The distance between the teeth of these racks corresponds with the desired length of the rings to be cut by the machine. The bar *B* may be either round or square, or as represented in the drawings, cross-shaped in section, in which case any desired number of racks up to four may be cut on the outer margins of the flanges of the bar. If the bar be round in section, any desired number of racks may be let into it in longitudinal grooves. Opposite each rack in the socket *K* are placed spring catches *h j*, which engage with

the teeth of the corresponding rack, and support the bar and swinging frame in position vertically. Provision is made for disengaging the catches from the racks, when it is desired to lower the swinging frame, by means of the cords *l l*, attached to the catches, passing over suitable corner-pulleys (of which one is shown at *N*, Fig. 192, attached to the ceiling or other support *O*), and extending downward, and terminating at *M*. The catches are forced inward against the rack by springs *p*, Fig. 193. A weight hung on the end of the cord *l* serves to withdraw the catch from engagement with the rack when it is not desired to employ the corresponding rack.

The lower arm *E* of the swinging frame is bent or curved horizontally, as represented in the drawings, Figs. 197 and 198, in order to permit of the swinging motion of the frame by which the pipe is severed into rings. The vibration of the swinging frame during the pipe-cutting operation, is represented by the dotted lines E' E'', Fig. 198.

The frame may be made of sufficient strength to sustain the wire *w* without the curved arm *E*; but it is preferable, for the sake of lightness, to employ it. Where it is not used the two rings *S* and S' should be connected by an upright bar, so that they oscillate together. A handle *T* may be affixed to the swinging frame. The wire *w* is strained across the lower part of the swinging frame, as represented in the drawings. It may be fastened at its ends by screw-clamps or by being twisted about a hook *a*, Fig. 196, or in any other suitable manner.

In order to prevent loss of time consumed in replacing

the wire when it is accidentally broken, the inventor attaches to the ring S' a reel c, Figs. 195 and 196, about which a supply of wire is wound. The reel-shaft i is provided with a ratchet f, Fig. 194, inclosed within a casing, which protects it from dirt, attached to the outer support r of the shaft, and which casing carries a catch g, by which the reel is prevented from turning in the direction in which the wire unwinds. When the wire breaks, all that is necessary with this arrangement is to raise the catch g, pull out the wire and secure it by twisting it about the hook a, or in any other suitable manner, and to strain up the wire tight by turning the reel by the handle d.

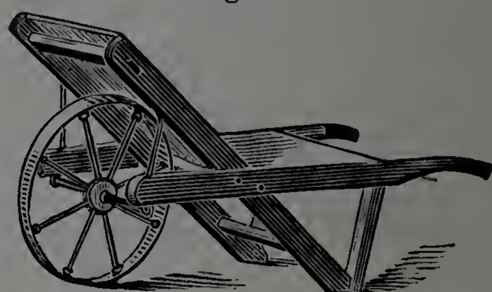
In the practical operation of this improved pipe-cutter, one or more of the pipes which it is desired to cut into rings being placed upright on the platform U, the operator swinging the frame backward and forward from the positions indicated by E' w', Fig. 198, to E'' w'', passes the wire through the pipe and severs it. At each end of the oscillating motion of the swinging frame, it is raised upward, or depressed for a distance corresponding with one of the teeth of the racks C or C', occupying in succession the positions indicated by the dotted lines in Fig. 198 and cutting a ring from the pipe while moving in each direction. A number of pipes may be cut into rings at one time, if placed on the platform U. After the completion of the cutting operation the rings, which remain on each other, are removed, and the operation repeated.

The inventor prefers to commence the cutting operation at the lower end of the pipe, moving the frame upward

between each cut, and using the handle *M* only, to disengage the dog *h* from the rack *C*, when it becomes necessary to depress the swinging frame.

The barrow shown in Fig. 199 is intended for wheeling sewer pipe and drain pipe, and it is built very substantially,

Fig. 199.



the wheel being of iron, and the remainder, with the exception of the back braces, being of wood.

The usual price of barrows of this class is $6.

CORONATION OF THE VIRGIN—LUCA DELLA ROBBIA.—Page 395.

CHAPTER IX.

ORNAMENTAL TILES, ETC.

SECTION I. GENERAL REMARKS.

THE earliest mention and description of a colored pavement in sacred history are about 521 B. C.; this pavement was at Susa, in the garden court of the palace of Ahasuerus, who is probably the Xerxes of Greek profane history. This pavement is described as "a pavement of red, and blue, and white, and black marble."—Esther i. 6.

The art of enamelling in glazed colors was well understood by the people of this locality at the time when the pavement was in use, as well as at an earlier period, as will appear from the description of the peculiar enamelled coffins which were used, and which will be described later.

Blue was a favorite color, and the red and blue of the pavement may have been enamelled tiles, and the white and black of marble.

At this time all manner of extravagances and dissipations were indulged in by this ruler; his kingdom extended over one hundred and twenty-seven provinces, from India to Ethiopia, and it was the custom of Xerxes to feast the

power of Persia and Media for long periods, and to display to them the riches and beauties of his glorious kingdom.

It was in a description of one of these feasts that the colored pavement was mentioned. Xerxes had exhibited everything in the way of magnificence to the guests, and "when the heart of the king was merry with wine," he commanded Queen Vashti to show the princes and the people her beauty, for she was fair to look upon.

Her oriental modesty would not allow this, and for her refusal, this tyrant divorced her, and the Jewess Esther was chosen to fill her place.

It is sad, but it is true, that it was at just such times of extravagance, dissipation, arrogance, tyranny, and oppression, that all classes of arts in very ancient times flourished and were stimulated to the highest perfection, and then quickly declined and were lost in the ruin that usually follows such epochs in the world's history.

It was in the same palace, and most likely in the court, that Nehemiah in great sorrow, three-quarters of a century later, heard from one of his brethren and certain men of Judah, that the remnant of the Jews left from the captivity in the provinces were in great suffering, and that the wall of Jerusalem was broken down, and the beautiful gates burned.

It has been often stated that the floor of the Temple of Solomon was a colored pavement. The temple was finished about four hundred and eighty-six years earlier than the time named in the commencement of this chapter, and it would be very interesting to know that the floor of this

most beautiful building was so paved. But in Kings vi. 15, we are distinctly told that the floor of the temple was covered with planks of fir.

The history of colored pavements probably followed the high perfection in brick-making, which flourished during periods of great extravagance.

Diodorus Siculus relates that the bricks of the walls of Babylon, erected under the orders of Semiramis, were decorated with all kinds of living creatures portrayed in various colors upon the bricks before they were burned.

The glazing in fixed colors came to us partially through the Arabians in Spain, who derived it from India, and primarily from China.

Glazed decorative tiles were much used in mediæval times for paving sacred edifices; they are sometimes called Norman tiles by old writers, from the supposition that they originated in Normandy. There are some specimens of great age in northern France; although no tiles have as yet been discovered in England that coincide with the features of the Norman style of architectural decoration, the most ancient being apparently of the thirteenth century.

The Normans were a race quick to seize upon every art that would add to the beauty of their buildings, either externally, or to the interior; and in the twelfth century, after the return of the Crusaders, many ornaments were added to their structures.

When the Crusaders visited Byzantium, Palestine, and Syria, they discovered buildings highly ornamented, and in

which glazed tiles were used, and they were attracted by many of the architectural features.

They carried back with them detail drawings of mouldings and designs, and among other things, glazed tiles, and most likely some knowledge of their manufacture.

The abbey of Voulton, near Provins, the hunting gallery of St. Louis, at Fontainebleau, a chateau near Quimperlé, St. Étienne d'Agen, and many other buildings offer curious specimens of Norman tiles, and the employment of decorative tiles about the same period was not less common or much less brilliant in England.

Stone had supplied all the wants of the Normans until the twelfth century. From this time new ideas everywhere appeared at once; tiles of red earth, of various forms, were substituted for stone; their surfaces were covered with a thin layer of white clay, in which were incrusted patterns of darker earth, or *vice versâ*. These baked enamelled tiles were not so easily worn by the constant steps of the faithful, as they were trodden every day in the vast naves of the churches by the feet of the Christian multitude. The tiles were arranged in a graceful chequer-work; trefoils, rosettes, and scrolls of notched leaves were formed and combined into graceful borders, sections of divided circles were ornamented with stars or heraldic suns; warriors heavily armed and clad in armor, and mounted upon richly caparisoned horses, were in active pursuit of one another; heads, busts, lions, eagles, and all other things that fancy and heraldry could jointly invent, animated the cold pavements; most of the ornamental combinations resembled the designs we are ac-

customed to see in the textile fabrics of the East; and we ought to be the less astonished at this when we remember the visits of the Crusaders to Syria, Byzantium, and Palestine, where this character of ornamentation was so largely employed from the ninth until the twelfth century.

The Normans, even at that early date, believed not only in massive details of construction, but also in the cheerful effects of a harmonious combination of colors and designs for interior relief.

All the rich Norman mouldings were copied by the English, and most likely a great part of the knowledge of the employment and manufacture of glazed tiles was imparted to them by their Norman neighbors.

They were a very energetic race; they took excessive delight in building; their princes and nobles seem to have taken their greatest pleasure in dwelling in and constantly beautifying their magnificent castles.

They did not care so much for feasting and high living as their English neighbors, who were greatly stimulated to construction by the example of these sturdy builders.

But no credit can be claimed by the Normans for having originated glazed tiles, as this, like many other decorative arts of Western Europe, was borrowed from the East by the Crusaders.

Many of the early Norman glazed tiles correspond with features of Byzantine architecture, from which the Gothic styles of architecture are also drawn quite as freely as from the Roman.

The idea, which is quite popular, that the art of painting

in enamelled colors, which afterwards became glazed or fixed to a clay body, originated about the ninth century with the Arabians in Spain, is clearly disproved by the glazed bricks of Babylon, the enamelled tiles from the ruined cities of the Desert, and the colored, glazed coffins of those Assyrian cities of the dead discovered by Mr. Kennett Loftus.

These glazed or enamelled coffins were in general use at Warka, Niffar, Zibizza, and other localities throughout Chaldea. In form, they resembled a slipper, but in symmetry and elegance they were models of beauty, their general design and finish displaying a high knowledge of the art of pottery.

The body was placed in the coffin through an oval aperture near the head, which was afterwards sealed with a neat fitting lid, cemented down with fine lime mortar.

In order to prevent the bursting of the coffin by the confined gases, a semicircular hole was left in the lower end.

The top was divided into square panels by raised ridges, which were sometimes plain, and at others very ornamental; each panel or division was relieved by a similar diminutive embossed warrior, measuring about six and one-half inches.

The small figure had its legs wide astride, a short sword belted at the left side, the arms akimbo, and the hands rested flat on a short fitting tunic. The head-dress was peculiar, and the general resemblance was similar to the figures on coins of the Parthian and Sassian periods.

Glazing of rich green enamel covered the entire exterior surface of the coffin, and within the color was blue.

The Arabs were attracted by the gold ornaments which

these coffins contained, and often broke and despoiled them in large numbers.

It is certain that the art of enamelling in the island of Majorca, where it reached great perfection, was derived from the Arabians in Spain.

The name majolica is applied to all tiles or earthenware having the ornament in relief, the embossed ornament and ground being decorated with various colored enamels.

The art of manufacturing and enamelling majolica ware was lost for a long period, but in the fifteenth century this ware, and the art of imitating ancient productions were highly prized by the Italians, under the names majolica and *porcellana*, from the Portuguese word for a cup, and Robbia ware after the sculptor who rediscovered it.

The first manufactory of this ware possessed by the Italians was erected at Faenza, in the ecclesiastical states, whence the French term *fayence*, now much used, had its derivation.

The body of the ware was usually a red clay, and the glaze was opaque; the oxides of lead and tin, mixed with potash and sand, were the usual ingredients employed in producing it.

This glaze was the discovery of Luca della Robbia, which, after the exercise of great patience and "experiments innumerable," he was enabled to apply, not only mechanically, but with great artistic skill.

Luca della Robbia was born at Florence in 1400 and died soon after reaching fourscore years, and in addition to

his fame as a great enamel painter, he ranked highly as a sculptor.

At a very early age he was apprenticed to the leading goldsmith of his native place; but his ideas turned to sculpture, and he soon began to model in wax with an unusual ardor. The only memorials of that period, which lasted until he was forty-five years old, are the bas-reliefs in the side of the Campanile towards the Duomo, and two unfinished reliefs in the Uffizi, Florence.

The first represents Music, Philosophy, Geometry, Grammar, and Astronomy; Plato and Aristotle; Ptolemy and Euclid; and a man playing the lute.

Those that are unfinished are the Imprisonment and Crucifixion of St. Peter.

There are also in the Uffizi the bas-reliefs made for the balustrade of an organ in the Duomo. These were undertaken in 1445, and most decidedly establish his claim to a very high rank among Italian sculptors. The position which they occupy is a very trying one, but they suffer nothing from it, although every opportunity for the most minute examination of them is accorded. They represent youths dancing, singing, and playing on musical instruments.

It may be that Luca studied with Ghiberti, as has often been stated, but of this there is no positive confirmation. He did, however, learn bronze casting with some one, as he made the doors of the sacristy of the Duomo.

He executed one of the finest of the many cinque-cento tombs for the Bishop Benozzo-Federighi of Friesole. A

portion of the decorations of this tomb were enamelled tiles painted with fruits and flowers in their natural colors.

Vasari accords Luca the credit of inventing enamel painting; he excelled in it, but it had long been practised by the ancient nations as has been shown, and from time to time by the Italians also.

Luca also introduced some changes by coloring his enamel for certain portions of the background, such as the plants, draperies, etc. He left a very large number of these works which are exceedingly beautiful. The frontispiece of this chapter represents one of Luca's latest productions.

In the Kensington Museum there are twelve medallions representing the months, and which are supposed to have been executed by Luca for the decoration of a writing cabinet for Piero de Medici. One of the most exquisitely beautiful of all these works in enamel is the "Coronation of the Virgin" in the altar-piece in the church of the Osservansa near Siena. After the death of Luca the secret of his method of enamelling was very carefully guarded by his family and was a great fortune to them, and they made a system of polychromatic architectural decorations.

Andrea, his nephew, and Luca II., the son, were employed for eleven years in decorating the Ceppo Hospital, at Pistoja, with a frieze which represents the seven acts of Mercy; the effect of this work is very pleasing as well as brilliant. Pope Leo X. employed Luca II. to pave the Loggie of the Vatican with colored glazed tiles.

Girolamo and Giovanni, brothers of Luca II., also worked in Robbia ware, and the first went to France and was much

employed by Francis I. in the decoration of his Chateau de Madrid, in the Bois de Boulogne.

Bernard Palissy about the middle of the sixteenth century, which was a century later than the early productions of Luca della Robbia, manufactured a similar article, but differently ornamented, which is called "Palissy ware." This ware is remarkable for its faithful imitation of animals and plants, as well as for its beautiful and gently blended glaze.

The patience with which Palissy prosecuted the discovery of this ware, his fortitude under successive failures in ovens and burnings, his hard labor, poverty and suffering for more than sixteen years, display energy and courage of a high order, and seem more like a romance than a reality.

The small fishes, frogs, reptiles, and grasses which he used in ornamenting the ware were taken from the rivers, marshes, and fields, and before they had time to wither were quickly cast in some rapidly setting composition. The mould was then carefully divided in any number of desired parts, and the animal or grass which served as a model removed, the grease with which it was covered making this quite easy without injury to the cast. The place of final manufacture was at Saintes, in France.

Not long after Palissy, the Dutch produced a ware similar in designs to the Robbia and Palissy wares; it was very substantial and well made, and they called it Delft-ware; but it was utterly destitute of those beautiful and gracefully expressive forms and painting for which the Robbia-ware of Faienza is so highly esteemed, and for which it will probably be remembered until the end of civilization.

The remarkable paving of the chateau of Ecouen has often been ascribed to Italians, the beautiful tiles are sometimes attributed to a member of the della Robbia family, at other times to a fugitive from the majolica manufactures, and some writers have even credited them to the talent of Bernard Palissy.

There is not the slightest question as to their origin; this indication of the place of their origin is inscribed among the arabesques, A. ROUEN, 1542, and the receipt of Masseot Abaquesne, enameller in earth, then living in the parish of Notre Dame de Sottevillelez, Rouen, for the final payment for this work was executed Thursday, March 7, 1548.

The reputation of Abaquesne had been made previous to the paving of the chateau of Ecouen. In 1535 he decorated a "salle faïencée" at the hotel known as the "Logis du Roi" at Havre, and in the manor-house of Bévilliers, near Harfleur, a pavement almost similar, inscribed 1536.

In 1557 Abaquesne gave a receipt in full and clear of all demands for the making of a certain number of enamelled tiles for the Sieur Durfe, as governor of the Dauphin (later the young and short-lived Francis II.), according to the designs which Durfe had given him for that purpose.

These tiles were possibly used in this "chateau de la faïencée," as Delorme styled it after being ousted from the direction of the works, and it is not at all unlikely that these same tiles found a place in the pavements of the chateau while under the direction of this identical Delorme in 1557.

The glazed tiles for decorative employments are usually of four classes, and are commonly called "art tiles," enamelled tiles, embossed majolica tiles, and encaustic tiles.

The first are usually hand-painted, and are employed largely for decorating grate cheeks, pilasters, and cabinet work; the enamelled tiles are also employed for the above purposes as well as for flower-boxes, wall linings, string courses, and other purposes of architectural decoration; and the embossed majolica tiles are also employed for the same purposes. Encaustic, plain, and Mosaic tiles are employed for pavements. Inlaid encaustic glazed tiles of extra thickness are used for hearths, and self-colored glazed tiles of white, celadon, turquoise, olive and buff colors in squares, or of geometrical form, are largely employed for wall linings.

Decorative tiles may also be described, according to their decorations, in another manner: First, those made with flat surfaces, and either of a natural or artificial monochrome without designs, called "self-colored tiles," or ornamented with surface enamel, or painting in outline, monochrome, or polychrome; second, those made with flat surfaces, inlaid in chromatic patterns to a slight depth, otherwise known as "encaustic tiles;" third, those made with designs in relief; fourth, those made with irregular, incised, indented, or depressed designs, having texture in the depressions. Either of the last two sorts may be painted in monochrome or polychrome, and either of the four sorts may be glazed either with a colorless glaze or with a colored glaze, or may be enamelled.

The great perfection to which this important branch of pottery has arrived in so short a period of time just past, is largely due to the great energy and practical intelligence of Mr. Herbert Minton, in England; and the firm of Minton

& Co. is so well known in connection with it that there is no necessity for enlarging upon their achievements.

The history of the revival in this line of manufacture commences, in England, with about the latter half of the present century. Mr. F. J. Wyatt's patent for imitating tesselated pavements with colored cement proved unsatisfactory, from unequal wearing, early in the century.

The experiments of Mr. Blashfield in this line with bitumen, colored with metallic oxides, also proved at first unsatisfactory; but he finally succeeded in some undertakings, and constructed an extensive and elaborate inlaid pavement on the plan of the Venetian Pise floors, after the designs of Mr. H. S. Hope, which is still in a good state of preservation at the country-seat of the designer.

One of the most important steps towards the revival of the art was the mode of Mr. Singer, of Vauxhall, for forming tesseræ by the cutting out of thin layers, pieces of the required form, which were afterwards dried and baked in the usual way. This patent also improved the method of uniting the tesseræ with cement, so as to form a slab of convenient size for paving, and some admirable mosaics were executed by him in this way.

In 1840, Mr. Prosser, of Birmingham, discovered that if the material of porcelain (a mixture of flint and fine clay) be reduced to a dry powder, and in that state be subjected to strong pressure between steel dies, the powder is compressed into about one-half of its bulk, and is converted into a compact, solid substance, of extraordinary hardness and density, much less porous and much harder than the common porcelain, uncompressed and baked in the furnace.

The applicability of this ingenious process to the manufacture of tesseræ for pavements soon afterwards occurred to Mr. Blashfield, who made arrangements with Messrs. Minton & Co. (the manufacturers appointed to work Mr. Prosser's patent) for a supply of small cubes, made according to the new process; these he submitted to various trials and experiments, and having found them in every respect suitable for the purpose, he, in conjunction with Messrs. Wyatt, Parker & Co., carried out the invention on an extensive scale. Tesseræ of various colors and forms—red, blue, yellow, white, black, brown; quadrilateral, triangular, rhomboidal, hexagonal, etc.—have been manufactured on this principle in large numbers. Pavements of considerable extent have been constructed with them, and they have been found to possess the following advantages:—

First, being formed in similar steel dies, they are of uniform size and shape, so that they can be fitted together accurately, in the laying down of the most complicated designs.

Secondly, being all composed of the same material, variously colored, they are all of precisely equal hardness, so that pavements made with them are not liable to wear into hollows by use.

Lastly, owing to the effect of the intense pressure under which they are made, they are quite impervious to moisture, of a flinty texture throughout, and, in a word, to all intents and purposes imperishable.

Another and later method than that invented by Mr. Prosser, that of using dust-clay, is known as the "Boulton and Worthington process," and is used by Malkin & Co. It

consists in the use of metallic boxes, fitted with plungers, and fashioned like the arabesques or other patterns, to be used as ornaments, in which the "design-clay" dusts are compressed within a frame, which frame is afterward,—the boxes and plungers being first removed,—filled with clay-dust of the ground color, which is compressed within the frame and around the pattern made as stated, and the whole then fired. But up to the present time, so far as I am informed, no relief-tiles or intaglio tiles having texture in the depressions have been made in whole or in part by compression out of clay-dust, and certainly no tiles, excepting Low's, having "undercut" designs have been made in any part out of compressed clay-dust.

The great and rapid progress that has been made in this refining art in England, is an achievement of which they are justly proud. Their hand-painted "art-tiles," richly glazed enamelled tiles, and embossed and glazed majolica, are marvels of beauty, considering the short time since the revival of the art of their production.

The tiles which have been named are very beautiful, and it hardly seems just to compare the present production of tiles with another branch of the ceramic art, and with a people who have fostered a national passion for the production of beautiful porcelain and enamel ware for more than a thousand years. But the subjects of hand-painted "art tiles," and glazed enamelled tiles of all kinds, are so closely allied to the glazed and enamelled porcelain productions of the whole world, that there is an almost irresistible impulse

to compare and examine the designs and enamels of old and new Japanese productions, and then we are sadly impressed with the fact that, with all our boasted culture, refinement, morality, and higher civilization, we are immeasurably their inferiors in this cherished branch of knowledge.

The artists of Japan are more truthful, sympathetic, and faithful in their delineations of birds, foliage, and flowers than we are; they seem to discover, as if by instinct, the salient points of natural objects, and to portray them in form so true, in feeling so soft and appealing, yet in manner of treating so strong and striking in all their details, that we pause, admire, wonder; but to imitate seems impossible.

"They confine themselves to no particular object; no one subject receives more care or consideration than another; from the highly cultivated, magnificent flower of gigantean proportions, to the humble, shrinking, modest daisy hiding away in the high grass, as well as the strong sturdy fir tree to the dwarf oak, that can hardly be seen, from the imaginative *Ho-ho*, down to the most insignificant inhabitant of the feathery kingdom in their sunny island home, all are treated impartially."

They not only excel in the rendering of animate and inanimate forms for decorative purposes, but their ingenuity in designing geometrical forms, and other conventional devices for the ornamentation of surfaces of all shapes is also superior to our adaptation for the same purposes.

As we stand in the Kensington Museum and gaze upon the specimens of Hizen ware, Satsuma faïencée, Ise, Kaga, Kiota, Owari, and other most beautiful productions of a

country abounding in glorious artists, there is pure admiration, unabased by any lower feelings.

As a people they are much closer observers than any other nation; in their holidays they gather from the woods and the fields natural objects, carry them to their city homes, preserve them as long as possible in all their beauty, and when they perish, reproduce them in artificial representatives.

But this branch of pottery does not belong to the present volume, and the expressions of admiration have been betrayed even as my eyes, at the instant of writing these words, feasted upon some beautiful specimens of the wares which have been named.

The effect of the highly glazed porcelain, the brilliant designs, the fabulous *Ho-ho* richly gilded, alternate panels ornamented with vases of flowers, which seem to yield a fragrance as sweet as they are beautiful, the perfectly harmonious colors of grounds, sometimes white, and next a rich deep blue, peaceful landscapes, and even the conventional ornaments so appropriately employed, make my every fibre quiver with pleasure and perfect sympathy.

The term encaustic has also been applied to glazed tiles of the kinds which have been described, and were it not already applied to denote an antique process of art, of a perfectly different nature, the term would not be inappropriate.

Encaustic tiles of the Middle Ages were produced by a method wholly distinct from that now employed.

The Norman tiles which have been mentioned are of this

character; the process was commonly adopted and employed in northern Europe from the twelfth to the fifteenth century, after which they fell into disuse.

The process of manufacture which, as it is supposed, was commonly employed, may be described as follows:—

The thin squares of homogeneous clay having been moulded and allowed to dry gradually until of the proper firmness, a design in relief was impressed upon them, leaving the ornamental pattern in cavetto; into the hollows or depressions thus left upon the face of the tile, clay of another color was impressed; the clay usually employed for the last operation was white, or pipe-clay.

The tiles were fully and carefully dried, and then partly burned, after which they were finished by covering them with a thin surface of metallic glaze, which was of a slightly yellow color, and, in the subsequent process of fixing this glaze in the furnace, the white clay beneath the glaze was tinged, and the red clay received a more full and rich tone of color.

To facilitate the equal drying of the tiles, as well as the burning, deep scorings or hollows were made on the reverse side, and in addition the pavement was more firmly held together by the cement, the bond being much stronger for it.

The sizes of these tile varied from about four inches square to six inches square, and their ordinary thickness was about one inch.

It was necessary that the shrinking nature of the clay should be about equal, and there is not the least doubt but that ingredients were used to act as a check upon the more

fatty clays, or otherwise most of the designs would be full of cracks from unequal shrinking, or the surfaces would bulge and be thrown upwards. Imperfections of these characters are not wanting; but their general infrequence would go to prove the employment of ingredients to equalize the shrinkage in drying and in burning.

Occasionally, either from the scarcity of white clay of suitable quality, in some locations, or for the sake of variety, glazed tiles of this character occur which have the design left hollow, and not filled in according to the usual process; but a careful examination of the disposition of the ornament will frequently show that the original intent was to fill these vacant cavities, as in other specimens.

But instances also occur where the ornamental design was evidently intended to remain in relief, the field and not the pattern being left in cavetto.

Among some of the oldest specimens of glazed tiles employed in England, may be mentioned the pavement discovered in the ruined priory church at Castle Acre, Norfolk, a portion of which is in the British Museum.

These tiles are ornamented with scutcheons of arms, and on some appears the name of "Thomas." They are exceedingly coarsely executed; the cavities are left unfilled with clay of a different color, and they are very much inferior to the Norman tiles of the same period.

It has been stated that glazed tiles of superior make and finish have been discovered in the priory church at West Acre, Norfolk; this priory was founded by Ralph de Tony, in the reign of William Rufus, for Canons of the Order of St. Augustine; this at the suppression was valued at three

hundred and eight pounds, nineteen shillings, and eleven pence half-penny. There was a close figuring for the ninth pound.

Malkin's process is now largely employed for the manufacture of inlaid as well as plain tiles; dried slip in the place of soft-tempered clay being used.

A brass plate, one-eighth of an inch thick, is used to produce the pattern, a separate one being used for each color. Thus, if it consists of an ornament in red and white on a blue ground, one plate is perforated, so as to enable the red portion of the clay powder to be filled in; another is cut for the white portion, and a third for the blue ground; when all are filled, the tile is subjected to an enormous pressure in a screw-press, the glazing being sometimes done in the first firing, and sometimes in a separate operation, as has been explained.

Encaustic tiles of one color are also now made of dried slip; these tiles are made by subjecting the powdered and colored clay to a great pressure in steel-lined moulds, having a raising plate bottom and an accurately fitting plunger; in this way one and one-quarter inch of fine loose clay is compressed into a little more than one-half solid tile.

Section II. The Manufacture of Mosaics and Imitation Inlaid, or Intarsia Surfaces.

Mosaics are often formed with tiles, made as described in the last paragraph of Section I. of this chapter, in which a great variety of forms and colors are employed to develop the pattern.

The Russian artists have of late years produced some beautiful specimens of mosaics in glass; the pieces of every shade and color are technically called smalts; they are generally opaque, and are set in cement the same as tiles.

In Greece, inlaid pavements of variously colored marbles were among the sumptuous decorations of the time of Alexander of Macedon. These were for the most part of fret work or geometric patterns, and known as the *Opus Alexandrinum*, but among the earliest mentioned, by Pliny, are those *lithostrata* formed of colorless tesseræ, the work of one Sosos of Pergamos, whose master-piece was the "Asaroton Œcon" or the "Unswept Hall," a representation of the crumbs and fragments which would be found on a floor after a banquet, together with a cantharus or two-handled vase from which a dove was drinking, while others were pluming and basking in the sun. By the third century B. C., the art had so far advanced, that, according to Athenæus, floors were laid down in the great ship of Hieron II. which were composed of small cubes of stone of every color, so as to represent the entire history of the siege of Troy; a work, the execution of which occupied three hundred workmen an entire year.

From Greece, the art was carried by Greek workmen to Rome, where it was known as *Opus Musivum*, expressing decoration produced by placing together small portions of stone, marble or glass, colored, either naturally or by art. It here acquired universal favor, and soon came to be applied not only to floors, but to walls and ceilings. The small pieces of which they were composed (from their resemblance to gamblers' dice, were called by the Romans tes-

selæ or tessaræ, from the Latin Tesselatum), were imbedded in cement in accordance with a predetermined design, and when the surface had been thus smoothed and polished, a reproduction of the design was there formed in a material as far as possible, exempt from change or ordinary decay. Pavements of this description are found wherever the Romans settled, no less than in Rome itself—in Asia Minor, Spain, Gaul, and England, and not only in large cities as in Carthage or London, but in the remotest villages and wayside villas. Scarcely a house of any size in Pompeii appears to have been without its mosaic pavement.

In the Middle Ages, this kind of work continued to be used in Italy, and some other parts of the Continent. The favorite pattern in the mediæval pavements is called "*Opus Alexandrinum*;" which was chiefly used in the twelfth and thirteenth centuries.

In England, it was never extensively employed, though used in some parts of the shrine of Edward the Confessor, on the tomb of Henry III., and the paving of the choir of Westminster Abbey, and Becket's crown at Canterbury, where curious patterns may be seen.

Mosaic-work of all kinds is still executed at Rome and Florence by the Italians, who display great skill in their combinations and colors.

Inventions are now being developed by which mosaics can be cheaply worked, which, of course, while the work does not compare in merit to that of Italy, and Russia, is at the same time suitable for many purposes of domestic ornamentation.

The contrivance shown in Figs. 200 to 203 is the invention of Mr. Robert Eltzner, of New York city, and is for the manufacture of mosaic plates for pavements, wall ornamentation, furniture, and other decorative purposes from natural and artificial material, such as marble, slate, porcelain, majolica, glass, jet, wood, and the like, so that any desired design can be produced without the employment of specially skilled hands, and thus very ornamental articles be furnished at reasonable prices for application in the arts.

The invention consists of a mosaic tablet or plate, the individual blocks of which are arranged face downward, according to a pattern or design on transparent paper that has been placed between two glass plates, so that light can fall through from below. The blocks of mosaic which form the plate are finally backed by means of a cement, leaving open joints, and stiffened with an exterior strip or band, as will appear more fully hereafter.

Figure 200 represents a perspective view of the table on which the mosaic plate is formed. Fig. 201 is a detail vertical transverse section of the same. Fig. 202 is a detail side view of a portion of the table, both figures being drawn on an enlarged scale, and Fig. 203 is a plan view of a mosaic plate formed on the table.

In carrying out the invention, a table *A*, of the size of the mosaic plate to be formed, is supported on a suitable stand *B*. The table *A* is made of an exterior iron frame A^1, and of two glass plates *a* and *b*, between which is placed the drawing of the design which is to be produced in mosaic. The design is made on transparent or translucent tracing-

paper, which is placed between the two glass plates with the face side downward, and secured by gum to the lower glass plate *b*. The thickness of the covering glass plate *a* increases with the size, weight, and thickness of the mosaic tablet to be produced. Upon the top glass plate

FIG. 201

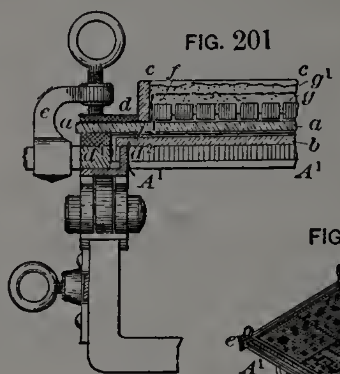


FIG. 202

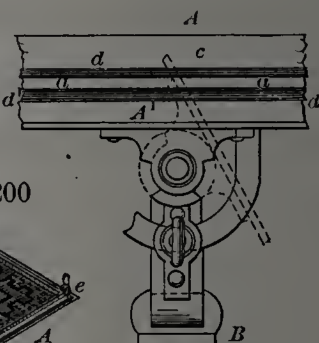


FIG. 200

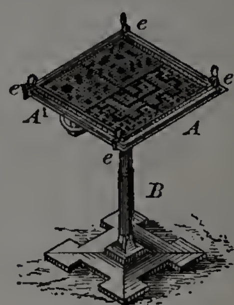
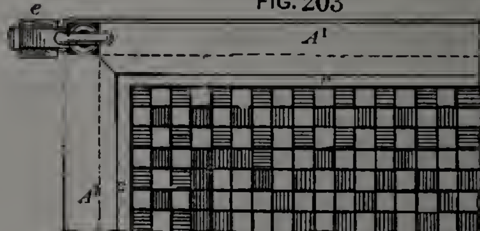


FIG. 203



a, a rectangular frame of upright glass strips *c* is placed, the corners of which are held together by stout paper strips pasted thereto. Below the glass strips *c* is placed a layer of paper, which covers the glass plate *a* outside of the glass strips *c*, so as to protect the surface of the former. Outside of the vertical glass strips *c* are arranged flat rubber strips *d*, also intermediate rubber strips d^1, d^2 between the

glass plates *a b* and frame A^1, the rubber strips d^1, d^2 and the clamps *e*, which are applied near the corners of the frame A^1, holding the glass plates firmly in position upon the iron frame of the table. The vertical glass strips *c* vary in height according to the thickness of the mosaic plates to be formed, and serve as the exterior walls for the cement backing which is given to the mosaic plate. A strip or band *f*, of galvanized wire-gauze, is placed in position along the inner surface of the glass strips, as shown in dotted lines in Fig. 201. The band *f* should not extend lower down than the depth of the joint between the blocks of the plates, for which purpose, so as to obtain the correct position of the band *f*, a flanged zinc strip f^1 is placed upon the glass plate *a*, below the rubber strips *d*, the zinc strips extending below the glass strips *c c* to the inside, its flange projecting upward along their inner surface for supporting the band *f*, as shown in Fig. 201. The individual blocks of mosaic, whatever be the material employed, are now placed in position upon the covering glass plate *a*, according to the design represented on the tracing-paper between the plates *b a*. As the light passes through the glass plates from below, it renders the configuration and colors of the design clearly visible, so that the exact position and color of the blocks required are clearly recognized. One row after the other, from the left to the right, is successively placed in position, the faces of the blocks being gummed, so that they adhere to the glass plate. If it be desired to bring out some portions of the design in relief, the remaining portions have to be covered with square glass plates of the size of the block,

so that the blocks placed thereon are set somewhat below the blocks without glass plates. When all the blocks are placed in position according to the design, the covering plate *a*, with the blocks remaining thereon, face downward, is removed from the frame for being backed and finished, while the table itself is ready for forming the next mosaic plate. For finishing the mosaic plate, the open joints between the blocks are now partly filled up with a layer of fine sand to the depth of the joints. As soon as this is done, a backing *g*, of a proper cement, plaster-of-Paris, or other suitable material, is spread into the joints and over the back of the blocks until they are covered to the thickness of one-eighth to one-quarter of an inch. A layer *g'* of wire-gauze is placed upon the cement and imbedded therein, after which it is covered with a thick layer of cement, plaster-of-Paris, or other material, to which, according to the thickness of the plate, sand or small lumps of stone are added. As soon as the cement backing has sufficiently set the clamping-screws are unscrewed, the paper strips at the corners of the glass strips *c* cut through, and the latter removed. The mosaic plate is then lifted off from the glass plate *a*, and placed face upward on a suitable setting-plate for final drying. The joints are then cleared of the adhering sand by means of a brush, and the mosaic plate is finished.

If desired, the blocks may be connected in a still more reliable manner by means of short metallic strips, which are cast in by the cement between the blocks, or by other means, as desired. In this connection it may be mentioned that the proper size of the working-table to be used is pref-

erably equal to four square feet, so that four mosaic plates each one square foot in size may be made at the same time, the separation of the plates being readily obtained by means of a dividing-cross of glass strips. If larger mosaic plates are desired, larger working-tables may be used. The frame of the table is preferably connected to the supporting-stand by means of a hinged joint and semicircular guide-rails, so as to be set into inclined position, by which the passage of the light through the design is facilitated. If extra large and heavy mosaic plates *h* are to be made, the lower glass plate *b* is made of several pieces, between which iron stiffening-rails are interposed.

The advantages of this improved method of manufacturing mosaic plates are that any desired design may be quickly produced without the employment of skilled hands, and that a number of hands can be employed at the same time to produce different plates. The plates can be made by daylight or artificial light, provided the colors on the design can be properly distinguished. As the joints between the blocks are open, a secure foothold is furnished when used for pavements. The plates do not require to be made of any great thickness, as the inclosing band and interposed layer of wire-gauze in the backing impart to them considerable strength and thickness.

Imitation Inlaid or Intarsia Surfaces.

The invention shown in Figs. 204 to 206 relates to the production, as distinctive articles of manufacture, of tiles, table-tops, wainscoting, panels, work-boxes, articles of furni-

ture of all kinds, and fancy or ornamental articles generally.

A mould or matrix is first prepared, of metal, slate, or any suitable material, and of suitable size and construction, in the bottom of which, or in the bottom and sides of which, the outlines of the ornament or ornaments with which the finished article is to be embellished are depressed, sunk, engraved, or intagliated. Into the mould or matrix thus prepared is placed the material, compound, or composition which is to form the base of the manufactured article. If this is to be an ornamental plaque, or a tile, for example, clay, plaster-of-Paris, or any artificial stone compound may be used, which is pressed into the mould, so that the intagliated lines in this will appear upon the plaque or tile, when this is withdrawn from the mould, as outlines of relief.

Almost any material, compound, or composition is capable of being used with and ornamented by this process, such as plastic materials or compounds, stone, wood, cast metal, or any sheet metal or metallic foil, such materials as are not themselves capable, on account of hardness, of receiving an impression in the mould or matrix being first covered or coated with a compound of a soft or plastic nature. Wood, by being steamed, boiled, or treated in several other well-known ways, is adapted for ornamentation by this process, either plain or veneered, and with or without a plastic coating of varnish, shellac, or any suitable paint composition.

Fig. 204 is a plan view of a plaque or panel with an imitation-intarsia surface. Fig. 205 is a section of the mould

or matrix; and Fig. 206 is a similar section, showing a modification in the construction of the mould or matrix.

In the treatment of some materials it is desirable to construct the matrix in the shape of rollers, one of which has a flat surface, and the other is provided with indented or engraved lines, which will form the outlines in relief upon the

FIG. 204

FIG. 205

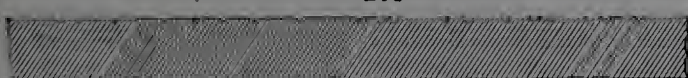


FIG. 206

material passed between them. When a hollow mould or matrix is used, this may be constructed as represented in Fig. 206, that is, with a raised or depressed part *a*, forming either a shoulder, as indicated by the full line, or a recess, as indicated by the dotted lines, at each end of said figure, which shoulder or recess, as the case may be, surrounds the engraved or intagliated bed of the mould, by which the ground or real surface of the article or material to be ornamented will be exposed in its natural state. By either of

these methods a base may be used which consists of several parts or layers, which allows of an endless combination and variety of materials adapted to be used by this process in the production of imitation-intarsia articles of manufacture, or articles of any kind ornamented by this process.

After the base has been produced with lines in relief in the manner described, and the spaces within the lines filled in with enamel, paint, or any suitable colored composition, and the surface rubbed down smooth, and varnished, if desired, as fully set forth, the article so prepared, if of clay and ornamented with mineral colors or enamel, is baked to give it the requisite degree of hardness and durability and bring out the colors. The subsequent treatment of the ornamented articles will, of course, differ according to their nature and the purposes for which they are intended; but the process of producing the raised outlines and subsequent filling in with coloring matter are in all cases substantially the same.

Section III. American Tiles.

The largest manufactory in this country for the production of encaustic paving tiles is that of the U. S. Encaustic Tile Company of Indianapolis, Ind.; their productions are good and are mostly vestibule and paving tiles.

The most prominent productions of decorative tiles are those from Chelsea, near Boston, Mass.

The good execution of designs in these tiles is fast making them very popular, and there is no doubt but that the

works at Chelsea are only the advance guard of numerous productive industries of this country, which are destined soon to lead those of Europe.

Nothing in the history of pottery is so remarkable as the progress which has been made in the manufacture of encaustic and decorative tiles, but especially in the latter, in this country since the Centennial Exposition of 1876—that grand industrial event in the history of this country, so creditable to Philadelphia and Pennsylvania, upon which city and State almost the entire burden has, to the perpetual disgrace of the government of the United States, been permitted to fall.

Sending tiles to Staffordshire may seem to the majority of Englishmen as a wild improbability, but ere long that fact will be established. One thing which aids us is, the tendency of English manufacturers in this line to lower the high standard of their wares and produce something cheap; a policy which is a great error. Indeed, this policy of sacrificing everything, including the actual producers themselves, to cheapness, too entirely dominates the English mind, with results which have been properly characterized as "cheap and nasty," and which also causes the brutalization of humanity.

All true art demands high standards, which must be rigidly adhered to; seek to elevate them you may, without harm; but to do aught to lower them is but to take a step on the road to its destruction.

Being at peace with all the world, and bending every

energy to develop to their utmost all those arts and employments belonging to a peaceful, energetic people, possessing ample talent and power of execution, we mean to excel if possible in all the branches of pottery production, and meet England in her own field, feeling that we are no longer dependent, and that henceforth we are competent in this line to care for ourselves, and although American designs may as yet be faulty as are those of Europe, so long as we have the foliage, fruits, beautiful landscapes, and God's well-shaped animals to guide us, we possess something equally good from which to draw inspiration for our designs.

Much credit is due in the production of decorative tiles to the arduous efforts of Mr. J. G. Low, of Chelsea, Mass.

The art tiles manufactured in this country had hitherto been poor in both design and execution, until Mr. Low turned his attention to imparting to plastic clay a new character of artistically finished and pleasing delineations of animate forms, flowers, and conventional ornaments.

We possessed nothing in this line of production that was a fit subject upon which we could lavish praise, or that in any way catered to our finer feelings. But that period is now happily past; the exhibition of 1876 injected into us as a nation new conceptions of the ideal, the natural, and the beautiful in art.

Symmetry, expression, and truth in no class of composition were generally appreciated; among a small proportion of the cultivated there were of course exceptions, and I do not mean now that the whole country has so rapidly been

educated in this particular; but do claim that a much larger number have been drawn to give time and study to this subject, and that the art schools of Boston, Philadelphia, New York, Baltimore, Chicago, St. Louis, and other portions of the country have been stimulated to achievements which are more than simply creditable.

The influences which such institutions exert upon all the arts and manufactures of our country cannot be over-estimated; there is no rule by which it can be computed, and no basis upon which to form a rule.

But that all the purposes of civilization, purity, and religion, or the opposite effects, can be greatly aided or retarded by the effects of art there is not the slightest room for doubt.

Eloquence, high power of analysis, and gentle persuasiveness are equally potent with delineative art in portraying to the mind the truths and principles which build up and strengthen character, and advance man in the paths of progress and industry, or that weaken and precipitate him in the sea of debauchery and indolence.

From the earliest times man has been enervated by such grossly sybaritic but artistically executed designs, so common upon the tiles taken from the ruins of Pompeii and other Italian cities; the luring songs of the siren have been effective in all ages; the downward path has at all times been easy to travel. To impede this and aid to combat it, art has also been employed in all its forms for good. Who can look upon the works of the gifted and chosen contained in Saint Peter's, Westminster Abbey, Canterbury, and other

cathedrals and some of the priory churches of western Europe, and view their paintings and mosaics on dome, ceiling, or walls, tread their tiled pavements, formed in all kinds of beautiful figures, bordered with flowers and traceries of vines, fruits and geometrical forms, and then fail to feel the elevating influences of art?

The effect of a harmonious design is similar to a sweet melody; it gently takes possession of us before being conscious that we have yielded to its influences.

In one plate we show a few specimens of the Low tiles, some singly, and others arranged in friezes and panels; it is, of course, not possible to do full justice to these designs in so limited a space; but there is an easy grace and spontaneity about them which can hardly fail to afford pleasure.

In other plates different designs for chimney-piece facings are shown, the names given to these facings being suggested by the salient feature of each design, "the bamboo," "the owl," and "Japanese quince," and the "lion," and "swag" ornament being the predominant features.

There are peculiar attractions in decorative tiles; pave a hearth, face a chimney piece or jambs with them, then light a fire in the grate, and in the winter evenings enjoy the magical effects, the changing play of light and shadow, and the various portions of the designs relieve monotony, and exert a soothing influence upon all, and the chimney corner becomes a home school for refinement in thought, in feeling, and in expression.

The success of Low's tiles has been steady, and at the same time rapid; for less than a year and one-half from

BAMBOO

Owl

Japanese Quince

LION

SWAG

Albertype Forbes Co


COBWEB FRIEZE
Low's
Patent Art Tiles
CHELSEA MASS U.S.A.
TEMPUS FUGIT
PANEL 2
TEMPUS FUGIT
PANEL 1
TEMPUS FUGIT
PANEL 3
660
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the commencement of their production we find them in competition with the productions of the most famous potteries in the world with the results of long experience to guide the selection of the articles exhibited, as well as a large and great variety in stock from which to select, on the part of their competitors, while on the part of the American tiles, the selection was hurriedly made from a then meagre stock, and hastily shipped to the place of competitive exhibition, which was at Crewe, England.

This exhibition was conducted under the auspices of the oldest and most influential agricultural society in Great Britain, which was the Royal Manchester, Liverpool, and North Lancashire Agricultural Society, and the first premium was a gold medal, value £10, which was awarded to Low's exhibit, and it was for the "Best collection of art tiles of English or American manufacture; hand-painted, impressed or embossed, relievo or intaglio."

The second prize, a silver medal, was awarded to one of the English exhibitors, one of the largest manufacturers in Staffordshire.

It should also be remembered that this competition and award of the first medal occurred in less than sixteen months from the incipiency of their manufacture of art tiles, and to all who are interested in American art and progress the success of these tiles should be a matter of great congratulation.

At the following exhibitions, the first medal was awarded to these tiles: American Institute Fair, New York, 1880, bronze medal; St. Louis Agricultural and Mechanics' Asso-

ciation, St. Louis, 1881, special award, silver medal; Massachusetts Charitable Mechanics' Association, Boston, 1881, gold medal.

Mr. Low completed a course of several years' study in Paris, in the *ateliers* of Couturé and Troujou. After this time, for a number of years, he devoted himself to decorative and scenic painting, in the mean time becoming greatly interested in the study of ceramics.

He eventually turned his attention to the study of the methods of tile-making, and commenced at the root, not shrinking from or in any way shirking the elementary labor, upon which so much after progress in all arts is due; he spent a year in the pottery, designing as well as imitating shapes; but the imitative part did not last long; he soon produced something which bore the stamp of his individual ideas. Then came the firing or burning of the ware, the erection of works and kilns, then other and more systematically conducted experiments, born of renewed earnestness.

Success crowned his efforts. This was not all that had to be done; it is sometimes easier to produce a good thing than to find a market; doubtless all who take interest in such things should at once buy them; but they do not, they wait, one or may be all think them very nice; but when it comes to the actual parting with the money it is altogether a different thing.

But so good were these tiles from the very commencement, and their merits so extraordinary and apparent, even of those which might be called primary, that the well-known furnishing house, Messrs. Wellington & Burrage, of Boston,

as soon as possible closed a contract with the Messrs. Low to take the entire output of their factory.

This kind of tile has everywhere given the greatest satisfaction; it does not assert itself by a glaring misapplication of colors; brilliant pictorial colorings are not in any way objectionable when the design is properly executed and the colors harmonize, which is too seldom the case; but the Low tile resistlessly attracts by the very simplicity and beauty of the single tones of glaze in which its modelled reliefs are dreamily suggested, and which appear like seemingly breathing forms.

These tiles have won their way by simple merit of execution, while many of the English tiles are upheld to-day not from any such cause, but simply upon the high and often inherited reputation of the house that produces them, and the heads of these houses are not and often have not been artists, nor have any of the junior members of the firm been so educated. But to speak plainly, and I certainly hesitate, much preferring that some stronger hand than that which now grasps so feebly this pen would write the words, I mean that English art in the whole line of artistic pottery has reached the highest point of development that it can ever attain under the present constitution of its society, and what is more, it has been stationary, but is now on a decline.

The art schools which are established in many parts of the kingdom may impede somewhat this fall; but the ultimate and complete destruction of this branch of art is but, under the present system, a simple question of time.

The saying: "Once a potter, always a potter," is literally

true, and if any interpretation can be put upon it, it means that they form a separate class or caste. However deserving, how many among those decorative artists who have reached the topmost points of their professions during the past quarter of a century, have attained the absolute control of any decorative pottery manufactory in England?

How many to-day are ever admitted into the different firms, in any sort of interest to entitle them to the slightest control?

Alas, not one, and potters they must stay; they cannot break away from the chains which hold them in their caste; they cannot establish themselves, no matter how much merit they possess; potters they must live, and potters die, as their fathers have done before them.

In the face of these facts, there can be but one result, or all past history is an error; to simply recall the effects of the caste system of Egypt is all that is necessary; it has been constantly the same; it is the great evil which has always, and everywhere, been destructive to art and progress.

It was the chief agent in the decline of Egypt; it was a bar to any progress, and discouraged all attempt at improvement; it crushed out personal ambition, the result being dull uniformity.

In Egypt the station of every man for life was fixed by caste, and the individual could not make his own way and fortune in the world, but must follow the accident of birth, and if his father was a potter, he must be one also.

In England, of course, there are no such laws written in the books and enforced, as other legal enactments, but it is

written and stamped into the customs of society, and such customs are often of much greater force than the strongest legal measures could possibly make them.

Mr. Low's invention, so far as it relates to surfacing tile, consists in the production and preparation of the moulds for embossing or indenting tile made of clay-dust, to the preservation and use of such moulds, to the formation of undercut figures by the aid of such moulds, and to the making of compact homogeneous clay-dust tiles, having surfaces ornamented in relief or intaglio having texture.

Figure 207 is a plan of a tile with an intaglio figure thereon, representing its use as a mould. Fig. 208 is a plan

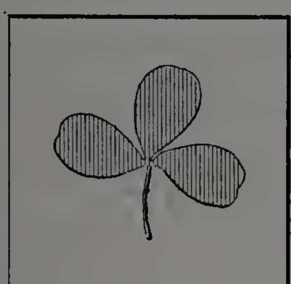


FIG. 207

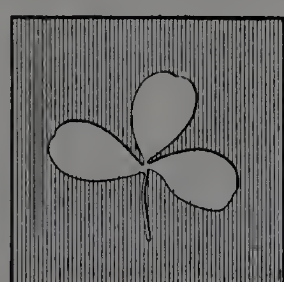


FIG. 208

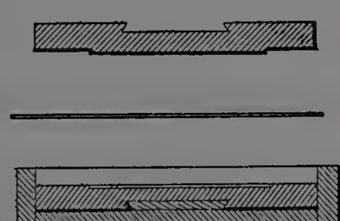


FIG. 209

of a tile with a figure in relief thereon, also representing its use as a mould. Fig. 209 is a cross-section, illustrating the manner of their use. Mr. Low uses a plastic material, like paraffine, and places it in the tile-frame of the tile-compress-

ing machine, and subjects it to pressure, thus producing a flat thin plastic plate of about the thickness of a tile; or he takes a quantity of clay-dust and similarly compresses it, and saturates this dust with paraffine. The upwardly-presenting surface of this plate is then plentifully sprinkled with pulverized plumbago, which is compressed into the surface of the plate.

The compressed plate may now be engraved with any desired pattern, care being taken to cover with black-lead powder, brushed on with naphtha, or any other solvent of paraffine as a vehicle, or dusted on to a slightly-warmed surface, or stippled on with a stippling-brush. The parts denuded by engraving can be used as an electrotype mould to make a reverse, and the electrotype used as a matrix to make an obverse. These electrotypes, well backed, as when used for printing, and set in steel or other strong boxes to prevent crush of the backing, will serve as dies for making the intaglios and reliefs for stamping tile in dry-clay dust.

In case high reliefs are desired, the paraffine (or better, the clay and paraffine) plate may be carved, as desired, carefully avoiding under-cutting, and then covered with its plumbago surface, by the naphtha process or stippling, and electrotyped and used as the die.

When high reliefs, which it is desirable to undercut, are to be made, the mould is made so that the compressed clay will draw, and the main part of the design being thus formed, the modeller carves the undercutting by hand, the clay being sufficiently tenacious when compressed to allow

this, and the finished tile, partly hand-made and partly machine-made, is then fired.

For obtaining textures, low reliefs, or intaglios of natural objects, and the like, the inventor may, if he desires, use the paraffine plate made, as has been described above, with plumbago surface, for electrotyping; but, instead of engraving it, he forms an impression in its black-leaded surface by the objects he wishes to represent, in the manner hereafter described for unleaded paraffine or clay-dust. It is preferable, however, as it gives great variety in design with slight expense, to adopt the following manipulation: Having formed the compressed plate, as already described, raise in the tile-frame of the tile-machine the lower platen till the upper surface of the compressed plate is conveniently near the top of the frame, and compose upon the surface, by laying thereon bits of woven stuff, lace, pieces of embossed paper, leather, or other fabric, leaves, grasses, flowers, or other objects having suitable textures and outlines, such a design as will be attractive; then lower the platen to place, and bring down the plunger with strong compression upon the objects. By this means they are indented in outline and texture in the plastic or clay-dust surface, even overlays being represented with an accuracy absolutely true to nature, and always in intaglio.

As already said, this intaglio may be used as a mould for electrotypes, when properly made, by use of pulverized plumbago as a surfacing agent; but the inventor usually takes this matrix so made, and places over it a diaphragm of thin tough material—a rubber film will serve, and many

other materials; but the best and cheapest is the thin Japanese paper, of uniform texture and great toughness, such as appears in the Japanese handkerchiefs and napkins, so called. This diaphragm must exactly cover the surface of the intaglio. Upon it is next laid the dust of surface and body-clay of the tile to be embossed, which is subjected to compression in the ordinary way, and thereupon, on raising the plunger and platen, the intaglio and relief may be separated, the diaphragm peeled by aid of a sharp tool to start it from the die, usually the relief, to which it generally, if not always, adheres, and the intaglio will usually, with proper care in handling, be found perfectly uninjured during several hundred impressions.

When the surface is of one clay and the body of another, each clay is to be separately compressed, unless *sgraffito* effects are desired, in which case the surface-layer must be carefully applied, so as not to cover the pattern desired to be of the color of the body-clay.

The sharpness and definition of texture of reliefs made from dust-clay intaglios are very remarkable, and tile compressed from dust from its homogeneous quality is much less likely to warp or shrink unevenly in firing than any other, particularly if packed in a less fusible powder, like quartz grains or canister in firing, as is not unusual with terra-cotta relief-work. By these means is obtained what has long been a desideratum in relief tile-work—a compact homogeneous embossed tile of uniform quality and slight shrinkage—more surely than has ever been done before.

It may often be desirable to obtain in tile both the relief

and intaglio of the impression in the clay-dust. In this case the relief can be used upon the platen in the same way as the intaglio. Two of these tile, an intaglio and a relief, may be placed face to face in the sagger for firing, and usually will separate on removal; but it is best to insure this by leaving the paper diaphragm between them.

In case the design is to be reproduced smaller, the shrunk fired tile may be black-leaded and electrotyped.

Of course these tile may have their intaglios filled with, or their reliefs covered with, kiln colors, slip, or enamel, either while simply clay or after firing, in any way and at any time proper in tile-making for such application.

No good method of fixing wall-tiles has yet been contrived, except those used by the ancients of flanging or bevelling the edges backward and forward on alternate sides or in alternating section on the same side, or in constructing them with holes partly parallel to their surfaces for cramps or wires extending into the plastic cement, all of which are costly, and none of which are adapted for compressed clay-dust work.

Lately on occasions, in wet-clay work, undercut cramp-grooves have been made by hand; but these are costly and inapplicable to dust-work.

Mr. Low employs the following means for forming dovetailed grooves on the backs of tile: He cuts one or more pieces of wood of dovetailed cross-section to such length as may be desirable, usually long enough to extend clear across one way, and lays them on the platen of the tile-machine, narrow side down, and fills in the clay-dust upon

them, or he places them on top of the filled-in dust narrow side up, according as the face of the tile is to be up or down. In compression the narrow face of the wood will be level with the back of the tile, and the clay-dust will mould round it. In firing, these formers will burn out, leaving their grooves, and this, if the wood be soft, light, and dry, without much, if any, chance of injury to the tile.

Many things may be used as substitutes for paraffines, such as waxes, and compounds of waxes, resins, gums, etc.; but I have not considered it requisite to enumerate them, as they would clearly be equivalents if their qualities of toughness, flexibility, and plasticity resembled those of paraffine.

The dust used should be fine enough to pass a one hundred-mesh sieve at largest.

Section IV. Process and Machinery for Manufacturing Flooring Tiles.

The machine shown in Figs. 210 to 219 is the invention of Mr. George Elberg, of Columbus, O., and is for the manufacture of flooring tiles by a new process.

He first prepares a thin sheet of clay on paper, which forms the finished surface of the tile-blocks. The second step consists in the method of cutting up the clay sheets into suitable blocks to make the finished face of the tile; and the third step consists in the method of combining the clay sheets with a suitable body of clay to be pressed and burned to make the finished tile-blocks.

Fig. 210 is a perspective view of a machine for making the veneered tile surface. Fig. 211 is a central cross-sec-

tion, showing the relative relation of the rollers shown in Fig. 210; Fig. 212, a side elevation of a machine designed for the second step of the process; Fig. 213, a front elevation of the same. Fig. 214 is an enlarged side elevation of the roller-adjusting mechanism shown in Fig. 212; Fig. 215, a broken section on line x x of Fig. 214; Fig. 216, a perspective view, showing detached parts of the treadle

FIG. 210

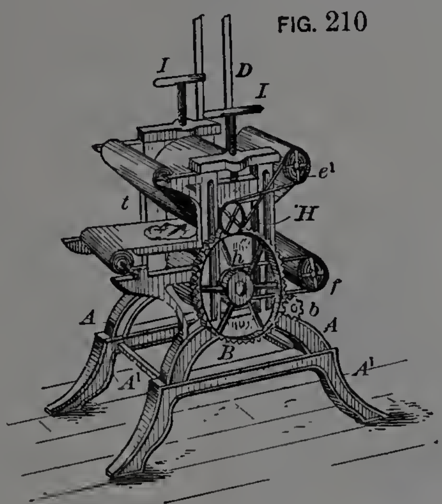
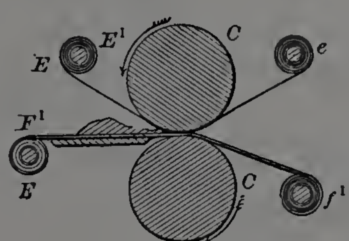


FIG. 211



mechanism; Fig. 217, a plan view of the cutting-dies; Fig. 218, a longitudinal section of the cutting-dies and follower-board; and Fig. 219, an elevation of the rack and pinion.

A represents the body or frame of the first machine; A^1, the legs on which the parts are supported. The frame of the machine may be made of any suitable material, and should be substantially built.

b represents a pinion mounted on a shaft supported in

journals on frame *A*, which is driven by a belt *D*, running over a pulley on the end of the shaft opposite to pinion *b*. Pinion *b* drives large gear-wheel *B*, mounted upon the axial shaft of roller *c*.

h represents a pulley on the same shaft.

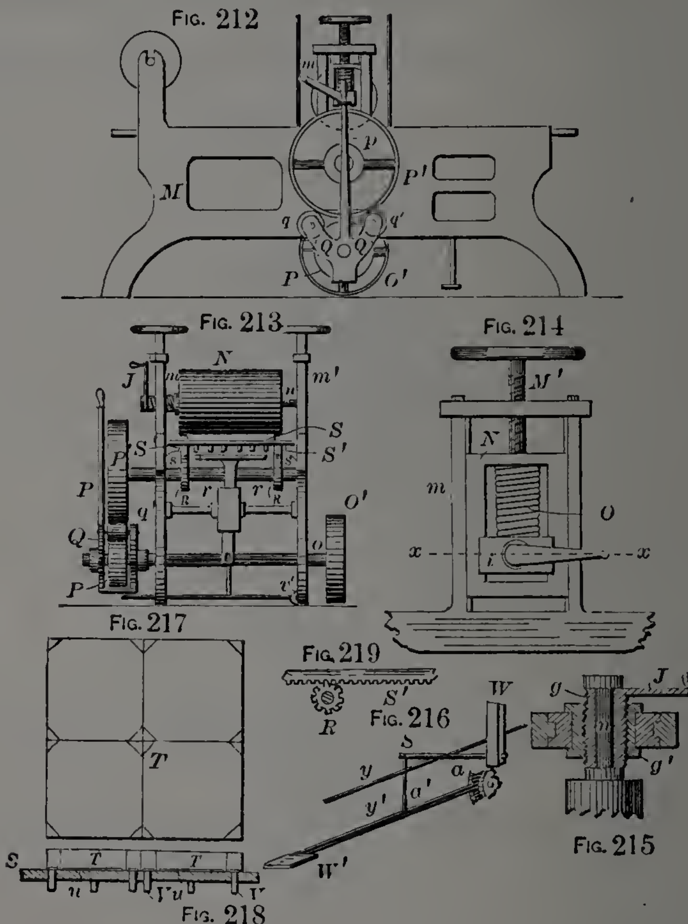


Fig. 212 Fig. 213 Fig. 214 Fig. 215 Fig. 216 Fig. 217 Fig. 218 Fig. 219

f represents a transmitting-pulley, mounted on axial shaft of roller *F*. This axial shaft of roller *F* is journaled upon the frame of the machine in any suitable manner.

H represents another transmitting-pulley, journaled to the frame of the machine on an independent shaft. Upon the outer end of said shaft is a transmitting-pinion, not shown in drawings, and meshing with gear *B*.

e^1 represents a pulley, mounted on the axial shaft of roller e, driven by a belt from pulley H, as shown in Fig. 210.

The paper may be burned off in the kiln, or removed after the tile has been completed and thoroughly dried ready for burning, leaving an excellent finished surface.

When delicate colors are to be used, it is preferable to remove the paper before burning; but in some cases the paper will burn off in the kiln without injury to the color.

The thin sheets of clay formed on paper I believe to be a new article of manufacture. The sheets of clay so prepared are united with an additional body of clay. The preferred process of carrying out this part of the invention is described as the third step.

The process of making the tile-sheet is as follows: A bolt of cloth is placed on roller E and one end passed around roller e, so as to be wound, as before explained; and in a similar manner a roll of paper is placed, leading from roller F to f', when the machine is ready to be started. Clay which has been previously worked and tempered so as to be highly plastic, is placed in bats of suitable size on the web of paper in front of roller C c, which are adjusted so as to have the space between three faces, the distance equal to the thickness of the sheet to be spread on the paper. Power is applied to the machine, when the rollers C c spread and press the bats of clay placed on the paper into a thin film upon the upper surface of the paper F, to which it adheres, and is wound with it into rolls upon rollers f', when it is ready for the second step of the process, which is performed

by means of cutting-dies, and the inventor has devised the following machine for carrying it on:—

M represents the frame of the machine; *m m'* guide-standards, placed upon either side of the machine; *N*, a soft-metal cylinder, journaled upon an axial shaft *n*. This cylinder forms a cutting-surface against which the edges of die-knives are pressed in the block cutting.

N' represents sliding journal-box frames, working in ways or guides between standards *m m'*.

M' represents an adjusting-screw, tapping through the cross-head of the standards *m m'* and swivelled to the journal-box frame *N'*.

O represents a coiled spring, seated between the box *i* of the shaft-journal and its frame *N'*.

g represents a screw-threaded sleeve, which forms the journal proper of shaft *n*.

g' represents a threaded bushing, through which the sleeve *g* passes.

J represents a crank-arm, rigidly secured to the sleeve *g*.

The bushing *g'* rests in the journal-box *i*. By turning the crank-shaft *J* the roller *N* is adjusted laterally between the standards *m m'*, so as to present different surfaces to the cutting-knives.

O' represents a driving-pulley, keyed to shaft *o*.

P represents a friction-pulley, mounted upon the opposite end of said shaft.

p represents a lever, journaled upon the end of shaft *o*, and having brackets or hangers *Q Q*, in the outer forked ends of which are journaled two small friction-rollers *q q'*.

Rollers q q are in frictional contact with the face of roller P, and serve as idlers when the lever p is perpendicular.

P' represents a second friction-pulley, which is driven forward or back as the friction-rollers q q' are brought alternately into frictional contact with pulleys P P' by means of the hand-lever p, which is moved to and fro to secure the desired direction of travel.

R R represent gears, keyed to shaft r.

S represents a reciprocating carriage, working in guides cut in brackets s s.

S S' represent rack-bars, attached to the under side of table S, the teeth of which mesh with the gears R to reciprocate the carriage S backward and forward as the lever p moved to the right or left. The carriage S carries cutting-dies T, which may be of any form or shape to give the desired configuration to the tile. I have shown a form or shape of ornamental tile of rectangular blocks t with pieces of right-angled triangular shape cut from each of the four corners, as shown in Fig. 217, so as to form lesser blocks between the carriers of the larger ones.

T represents the blade of the die-knives, the backs of which rest on carriage S. Each of the lines in Fig. 217 represents the cutting-edge of the die-knives.

u represents follower-plates of the same shape as the blocks or die-knives, resting on carriage S between the knives T.

V represents pins fastened to the follower plates, which project through holes pierced in the table S.

W represents a post which carries a platen, and is operated by a compound treadle, *W′*, pivoted to frame *M.*

a represents an arm rigidly attached to post *W*, which carries the platen. This arm *a* is pivoted upon a fulcrum-rod *y*, and to arm *a′* at *s′*, the parts *a*, *a′*, *y*, and *y′* forming a compound treadle-lever by which the platen *W* is raised.

The second step of the process is performed by the apparatus shown in Figs. 212 to 219. A roll of paper covered with the thin coating of clay formed by the first step is placed in the forked standards *M″* and opposite the cylinder *N.* Carriage *S* is withdrawn from under cylinder *N*, and one end of the sheet-clay is drawn over the cutting-edge of knives *T*, when the operator takes hold of handle *p*, moves it forward, and brings friction-pulleys *q* into contact with pulleys *P* and *P′*, which carries the knives with the sheet of clay under the cylinder *N* and cuts the sheet-clay into the desired shape for tile, which blocks fall down and rest on the follower. A reverse movement of lever *p* will reciprocate carriage *S* out from under cylinder *N* in position for a second operation, and this is repeated until it is necessary to remove the blocks from the die-knives, when the operator places his foot on treadle *W′*, and raises platen *W* and the follower-plates, which lift the block out of the dies, from which they are removed ready for the third step of the process. The thin paper clay sheets cut into the desired shape of the tile are used to form the finished surface of the tile. These sheet-blocks so cut are placed paper side down in the bottom of moulds of the required depth, and of an outline corresponding to the shape of the cut sheets and of the tile. The

clay or upper surface of these sheet-blocks is slushed (moistened) with layers of moist clay. Then a block or sheet of clay of the corresponding shape and of suitable thickness is placed on the slushed sheet in the bottom of the mould. A coarser and less-carefully prepared quality of clay can be used for this filling. The slushing-layers cause the two to unite or adhere together, and they absorb the moisture of the slushing-layer, and become of the same temper. The blocks are then dried sufficiently to be pressed. After being pressed they are dried, and then placed in a kiln and burned in the usual manner.

Roller *C* is mounted in sliding journal-boxes, working in ways in the frame of the machine, and vertically adjusted by means of hand-wheels *I*, keyed on screw rounds swivelled to the journal-boxes.

E is a roll the axis of which is journaled on the bracket *l*.

E′ represents a roll of cloth, wound or unrolled from roller *E* and wound upon roller *e* by means of the belt passing over pulleys *H e′*.

F′ represents a roll of paper, wound in a similar manner from roller *F* upon roller *f′*. The several rolls *E e F f′* are journaled in such a manner as to be readily detachable as fast as webs of cloth or paper are wound off of the rollers *E* and *F*, when a new roll is placed in position for a similar winding.

The object of this machine is to prepare thin sheets of clay with a finished face, which is formed by being pressed upon and adhering to paper *F′* by the operation of rolls *C c*.

In order to prevent the clay from adhering to the upper roll,

fine muslin or other porous endless web F' is caused to pass between the clay and the roller C. Paper is used on which to press and roll the thin sheets of clay, for several reasons. It gives a smooth, fine finish to the clay; and, being flexible, allows it to be wound into rolls as fast as made, which is a very advantageous form for handling in the second stage of the process, and the paper preserves the surface of the base to which it adheres while the second and third steps—that of cutting and uniting this thin sheet with another body of clay to form the tile—are being performed. It also prevents the spreading of the color, and preserves it intact in the succeeding steps, and prevents spotting or soiling of the clay while it is being handled and dried.

The object of the machine shown in Figs. 220 to 228 is to press the tile on carrier-plates, which are first oiled; then the clay or tile blank is placed upon carrier-plates, passed under an oil-roller, thence carried between dies and into a die box, where it is subjected to pressure to shape and form the tile, then delivered out of the dies by the automatic and intermittent action of the machine driven by power, the motion of the machine being imparted by means of an oscillating shaft, from which shaft all parts of the machine primarily take their motion to successively carry out the various steps of the operation.

Fig. 220 is a side elevation of machine for oiling the carrier-plates; Fig. 221, an end elevation of the same. Fig. 222 represents the carrier-plate. Fig. 223 is a perspective view of the pressing-machine; Fig. 224, an end elevation of the same; Fig. 225, a plan view of the reversing-gear; Fig.

226, a longitudinal section on line x x Fig. 224; Fig. 227, a detail view of one of the outside eccentrics operating the die-arms; Fig. 228, a detail view of die-arm with die removed.

A A^1 A^2 represent the frame of apparatus; a^1, an endless

FIG. 221

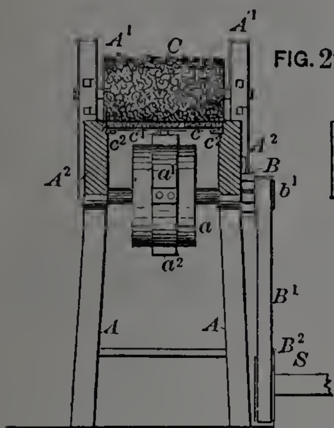


FIG. 220

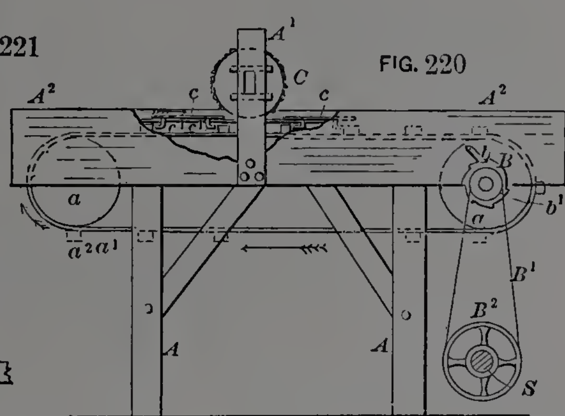


FIG. 222

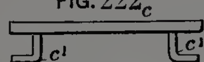
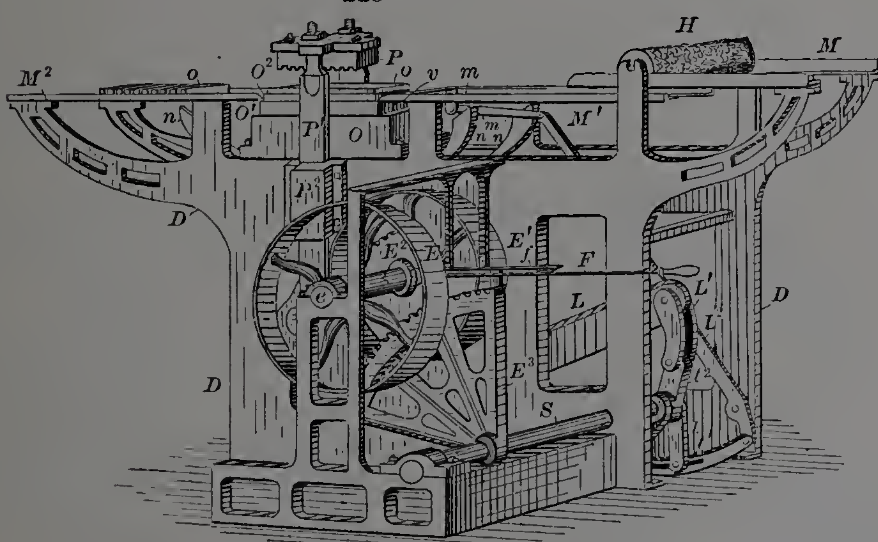


FIG. 223



carrier travelling over pulleys a a; a^2, carrier-blocks secured to belt a^1; B b, a ratchet and pawl; B^1, a belt connecting pulley b^1 to driving-pulley B^2, rigidly secured to shaft S.

C is a roller covered with sheep's pelt or other porous substance designed to hold oil; *c*, the travelling plates, on which is placed the clay. c^1 are depending legs or hooks

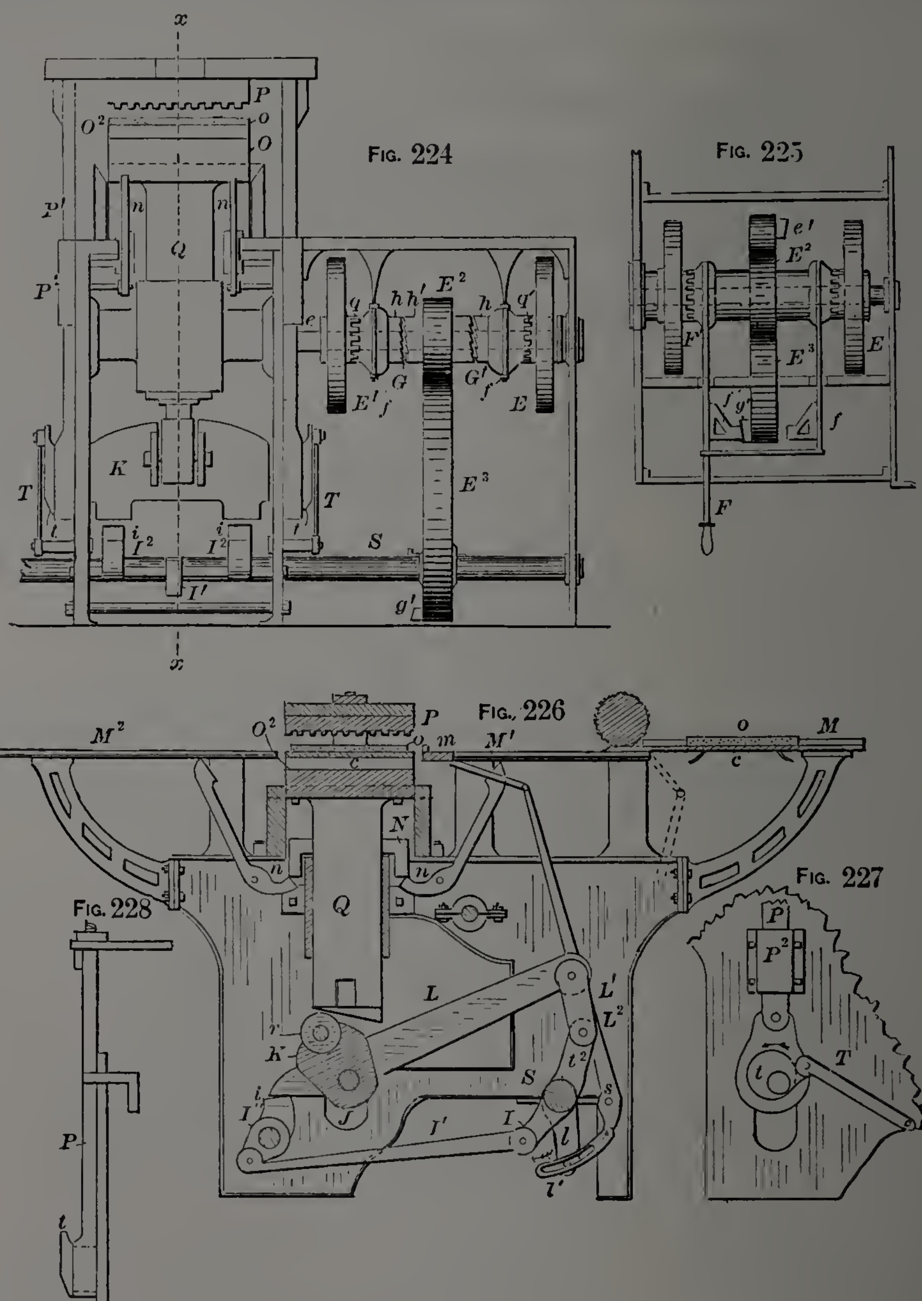


Fig. 224

Fig. 225

Fig. 226

Fig. 227

Fig. 228

engaging with the carrier-blocks a^2; c^2, angle-irons, which act as ways for plates *c*. The plates *c* are placed upon the

angle irons or ways c^2, then, by means of the carrier-blocks a^2, are carried under roller C, which oils the surface. When they reach the other end of the machine they are taken off by the operator and blanks of clay placed upon them, when they are ready for the second step.

D represents the framework of the pressing-machine; E E', driving-belt pulley-wheels, running in opposite directions, and mounted upon sleeves h, loosely rotating on shaft e.

E^2 represents a pinion mounted upon a sleeve tight upon shaft e.

E^3 represents a quadrant-gear having teeth meshing with those of pinion E^2, and mounted upon and keyed to shaft S.

F represents a shifting-lever, and f a shifting-frame for moving the sleeves h laterally upon shaft e; G G', clutch-teeth on the ends of the sleeves h h, which engage with similar teeth upon either end of clutch h'.

q q' represent clutch-gears upon the inner hubs of the pulleys E E' and the outer ends of the clutches h, so as to allow the lateral movement of either of clutches h to engage with clutch h' for communicating motion from either of the pulleys E E' to pinion E^2.

H represents a roller covered with porous substance, similar to roller C, for oiling the top of the clay out of which the tile is to be formed.

L L' indicate a compound link-lever, operated by shaft S by means of the crank-arm l^2 in the manner hereafter described.

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L^2 l l' m' indicate reciprocating adjusting mechanism connected to the adjusting-plate m, which travels on angle-iron ways M'. Lever L^2 is pivoted to the frame of the machine at s and connected by a slotted link l' to the crank-arm l, secured to the shaft S.

M'' indicates angle-iron ways on the opposite end of the machine, on which plate c travels after being acted upon by the dies.

M indicates angle-iron ways, which are elevated in a plane above the ways M', so as to allow the adjusting-plate m to pass under the carrier-plate.

n n are adjusting or centering triggers.

O is the casing or die box to hold die-plates in pressing; O', the top face of the plunger piston; o, the clay or tile-blank; P, the upper die-plate; P′, vertically-sliding arms secured to plate P.

P^2 represents guides, which are grooved to receive arms, P'.

I I' I'' i represent a crank-lever and eccentric mechanism; J, a slot in the frame of the machine.

When the operator removes the plates from the machine shown in Figs. 223 and 228, and fills them with blanks of clay, he places one upon ways M and pushes it forward under the roller H to oil the top of the blank to prevent its sticking to the die. Meanwhile the quadrant E^2 oscillates to the right, carries arm l in the direction shown by the arrow, thus drawing link l' in the same direction, and throwing arm L^2, pivoted at s, to the right. This carries the adjusting-plate m with it back under the ways M upon ways

M', as shown by dotted lines, Fig. 226, so that when the plate *c*, with clay *o*, passes out from under roller *H*, and drops down upon ways *M'* the adjusting-plate *m* will be in the rear of it. When the shaft *S* rotates in the opposite direction, the motion is reversed and the plate, with the tile-blank, is shoved along ways *M'* between the dies. When the shaft *S* rotates to the right, the arm l^2, operating link *L'*, draws arm *L* downward. At the same time the arm *I*, travelling to the left, operates arm *I'*, thus rotating eccentric I^2, and allowing the press-beam *K* to drop down in slot *J*. Both ends of the arm *L* move down without changing the inclination and in unison with press-beam *K*, so that when press-beam *K* reaches the bottom of the slot *J*, the inclination of arm *L* is unchanged. The plunger *Q*, resting upon roller *r*, journaled in beam *K*, drops with said beam. As soon as the plunger *Q* begins its downward motion, the arms *N* engage with triggers *n* and operate them so as to close upon the plate *c* and centre it upon the plunger, when it is ready for the pressure. When the plunger and beam *K* drop, they carry the top die *P*, and arms *P'* down, and this motion, by means of arm *T*, pivoted to the frame of the machine and to the eccentric *t*, rotates the eccentric, as shown by arrow, and throws arm *P'* down, so as to draw the top die *P*, down upon the clay. These motions are all simultaneous with the downward motion of the plunger *Q*. After the beam *K* reaches the bottom of slot *J*, by the continued downward motion of the link *L'* and arm *L*, the roller *r'* is brought to act upon the inclined bottom of plunger *Q*, and, travelling to the right, raises plunger *Q* so as to lift

plunger Q up and press the clay between the dies O^2 and P, and form on the surface any desired ornamental figures or ribs conforming to the face of the dies. When the quadrant F^3 has revolved far enough to the right to cause these motions to be performed, they are stopped by means of a lug g' upon its periphery engaging with the bracket f', as shown in Fig. 225, throwing the frame f over, so as to cause clutch-sleeves h to slide upon shaft e and throw loose sleeves of wheel E' out of engagement, and at the same time that of wheel E into engagement with the other end of the sleeve h', thus reversing the motion of the quadrant, and with it the motions of the various levers and arms before described. Lever F is moved to the right or left, so that sleeves h may be thrown out of or in gear at any period of the operation of the machine, and the motions instantly reversed at the will of the operator. In order to allow the operator to stop the machine at any point of its operation, the sleeves h h are set far enough apart to allow the clutch-sleeve h' to rotate freely between them. Lever F and frame f are attached to clutch-sleeves h h, so that both may be disengaged from the clutch-sleeve h' by a partial throw of lever F, as shown in Fig. 225, or the motion may be at any time reversed by a full throw of the lever. The die is emptied, and the machine set for a second operation by reversing the motion by lugs e' g'. The beam K, being raised by means of the eccentric I^2, carries the arms P', together with the eccentric t upward, and because the link or arm T is pivoted to the frame of the machine, arm T draws the eccentric over to the right until it resumes the position shown in

the drawings, Fig. 227, thus raising arms P' so as to lift the upper die P clear of the clay, and above the plane of its travel, which allows the pressed tile, together with the plate c upon which it rests, to be pushed forward on ways M^2 by the next succeeding plate, as shown in Fig. 223. These motions are repeated automatically and successively, rendering the management of the machine very simple and easy. When the tiles pass out of the die upon the ways M^2 they are taken by the operator and emptied, and the plates c placed upon the ways of the machine (shown in Fig. 220), when the same operations are repeated.

The machines shown in Figs. 220 and 223 are placed side by side, the pulley B^2 being mounted upon and driven by the same shaft S, as quadrant E^3. The legs or hooks c' on the bottom of plate c serve as handles for the operator to remove them from and replace them upon the machine. The pulley b' is attached to the shaft of pulley a by any usual clutch device, which allows it to run backward as an idler, when shaft S moves to the right. When the motion of shaft S is reversed, ratchet and pawl B b checks the backward movement of the carrier belt or apron.

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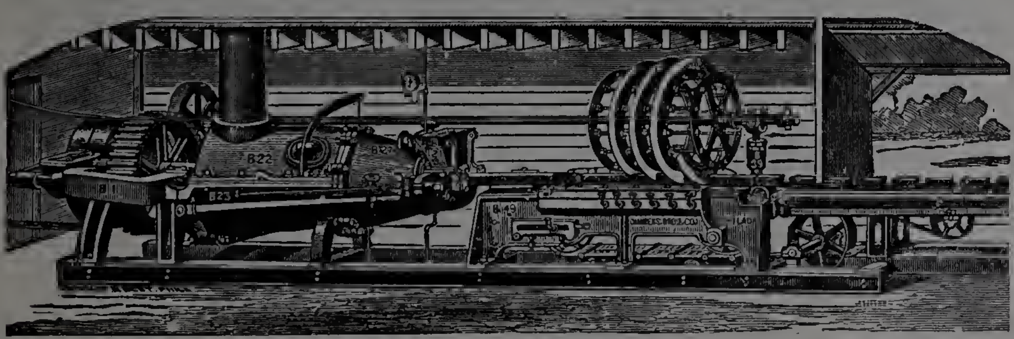

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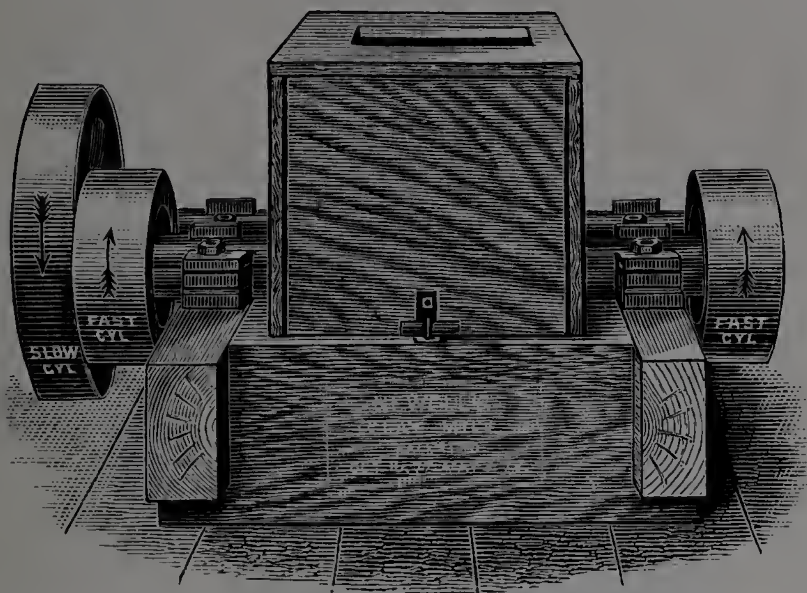

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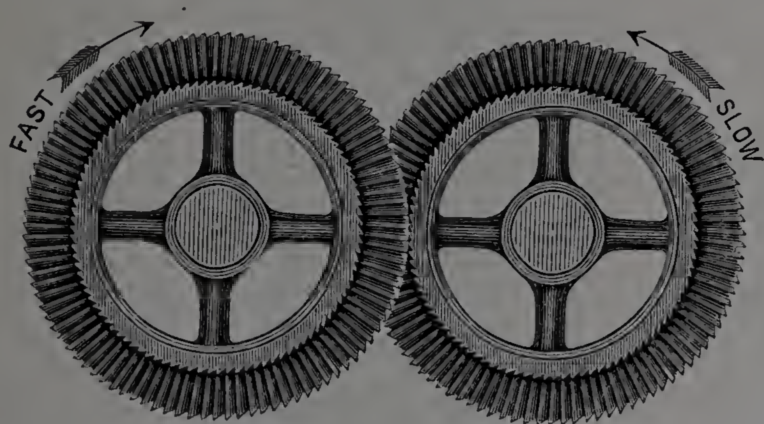

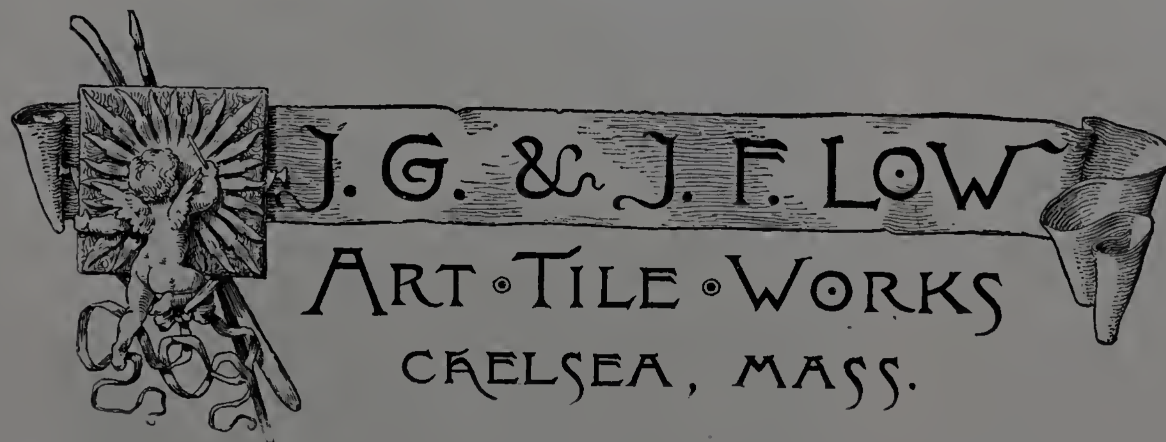
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